Washington Township Health Care District

2000 Mowry Avenue, Fremont, California 94538-1716 • (510) 797-1111

Nancy Farber, Chief Executive Officer

BOARD OF DIRECTORS' MEETING

Wednesday, March 9, 2016 – 6:00 P.M.
Conrad E. Anderson, MD Auditorium

AGENDA

		PRESENTED BY:
I.	**CALL TO ORDER & PLEDGE OF ALLEGIANCE**	Michael Wallace Board Member
II.	**ROLL CALL**	Christine Flores District Clerk
III.	**EDUCATION SESSION:**	
	Cancer & Breast Health Program	Vandana Sharma, MD, PhD
IV.	**CONSIDERATION OF MINUTES**	
	February 10, 22, 24, and 29, 2016	*Motion Required*
V.	**COMMUNICATIONS**	
	A. Oral	
	B. Written	
	From Kranthi Achanta, MD Chief of Staff, Dated February 22, 2016 requesting approval of Medical Staff Credentialing Action Items.	*Motion Required*
	Intensivist Directed Critical Care Model	Kimberly Hartz Senior Associate Administrator Albert Brooks, MD Chief of Medical Affairs Kranthi Achanta, MD Chief of Staff Carmencita Agcaoili, MD Medical Director, Intensivist Program

		PRESENTED BY:
VI.	**INFORMATION**	
A.	Service League Report	Debbie Jackson Service League President
B.	Medical Staff Report	Kranthi Achanta, MD Chief of Staff
C.	Hospital Calendar	Nancy Farber Chief Executive Officer
D.	Lean/Kaizen Report	Kimberly Hartz Senior Associate Administrator Donald Pipkin Chief of Strategic Management
E.	Construction Report	Ed Fayen Senior Associate Administrator
F.	Quality Report Quality Dashboard – QE 12/2015	Mary Bowron, DNP, RN, CIC Senior Director of Quality & Resource Management
G.	Finance Report	Chris Henry Associate Administrator and Chief Financial Officer
H.	Hospital Operations Report	Nancy Farber Chief Executive Officer

VII. ACTION — *Motion Required*

A. Consideration of Neuro Drills

B. Consideration of Increased Data Storage for Electronic Health Information Growth

C. Consideration of Clinical Quality Metric Software

D. Consideration of Perinatal Clinic Electronic Health Record Build

E. Consideration of Resolution No. 1164 Authorizing Chief Executive Officer to Enter Into Agreement With The Principal Financial Group Regarding Certain Retirement Benefits

VIII. ADJOURN TO CLOSED SESSION

In accordance with Section 1461, 1462, 32106 and 32155 of the California health & Safety Code and Sections 54962 and 54954.5 of the California Government Code, portions of this meeting may be held in closed session.

A. Report and discussion regarding California Government Code section 54957: Personnel matters

B. Conference regarding medical audit reports, quality assurance reports and privileging pursuant to Health & Safety Code Section 32155.

C. Report involving a trade secret pursuant to Health & Safety Code section 32106

New Program

Estimated date of public disclosure: March 2017

IX.	**RECONVENE TO OPEN SESSION & REPORT ON CLOSED SESSION**	Michael Wallace Board Member
X.	**ADJOURNMENT**	Michael Wallace Board Member

CALL TO ORDER

A meeting of the Board of Directors of the Washington Township Health Care District was held on Wednesday, February 10, 2016 in the Conrad E. Anderson, MD Auditorium, 2500 Mowry Avenue, Fremont, California. Director Wallace called the meeting to order at 6:01p.m. and led those present in the Pledge of Allegiance.

ROLL CALL

Roll call was taken: Directors present: Michael Wallace; William Nicholson, MD; Bernard Stewart, DDS; Jacob Eapen, MD; Patricia Danielson, RHIT;

Also present: Nancy Farber, Chief Executive Officer; Kranthi Achanta, Chief of Medical Staff; Debbie Jackson, Service League President; Christine Flores, District Clerk

Guests: Kimberly Hartz, Ed Fayen, Chris Henry, Bryant Welch, Stephanie Williams, Tina Nunez, Kristin Ferguson, Mary Bowron, John Lee, Albert Brooks, MD, David Hayne, Angus Cochran

EDUCATION SESSION: Beaker Implementation

Nancy Farber, Chief Executive Officer introduced John Lee, Chief Information Officer. Mr. Lee presented the Beaker Implementation Review sharing what Beaker was. Beaker is Epic Systems Clinical Laboratory solution that integrates with our current WeCare Electronic Health Record system to accommodate most of the critical functions performed by our Washington Hospital Lab Department. It is typically implemented over a 12-18 month period of time and includes interfaces with other internal WHHS lab solutions such as Horizon Blood Bank and Sunquest Anatomic Pathology. Beaker also connects to external entities including results reporting to the California Department of Public Health, orders and results transfer with our primary reference lab ARUP at the University of Utah and real time input to our predictive analytics model at the Parkland Center for Clinical Innovation (PCCI) to name a few. Beaker provides a mobile care solution called Rover for our phlebotomists and includes a scan-based workflow that enables staff to improve patient safety via positive patient identification. Mr. Lee continued by sharing Beaker team goals, implementation challenges, testing, lab team members, training, the Go Live Plan, the project results and Beaker achievements.

Zika Virus

Nancy Farber, Chief Executive Officer introduced Dianne Martin, MD, Infection Disease consultant and Albert Brooks, MD, Chief of Medical Affairs. Dr. Martin presented a Zika virus update sharing what the virus is as well as the countries and territories with active transmission. Dr. Martin continued by sharing the symptoms, the course of illness, diagnosis, management, prevention of the virus, and the risk factors of infection during pregnancy. Dr. Brooks shared the transmission cycle of a person infected to another person as well as possible transmission from mother to baby during pregnancy. Dr. Brooks continued by sharing what is known about the effects of Zika virus on pregnant women, the association between Zika and congential microcephaly, and association between maternal Zika virus infection and other adverse pregnancy outcomes. Dr. Brooks went on to share facts about microcephaly as well as CDC’s interim guidelines for pregnant women during the Zika virus outbreak; recommendations for pregnant women considering travel or have a history of travel to an area of Zika virus transmission and how to treat pregnant women with diagnosis of the virus were also shared.

APPROVAL OF MINUTES OF JANUARY 13, 25, AND 27, 2016

Director Nicholson moved for approval of the minutes of January 13, 25, and 27, 2016.

Director Stewart seconded the motion.
Roll call was taken:

Michael Wallace – aye
William Nicholson, MD - aye
Patricia Danielson, RHIT – aye
Bernard Stewart, DDS - aye
Jacob Eapen, MD - away

The motion carried.

COMMUNICATIONS: ORAL

Director Wallace opened the floor to communications from the public. Laurie Miller, Kim Lake, Donna Burdusis, Kim Sullivan and Michelle Vo were invited to address the Board. The speakers addressed the Board regarding California Nurses' Association (CNA) negotiations.

COMMUNICATIONS: WRITTEN

The following written communication received from Kranthi Achanta, M.D., Chief of Staff, dated January 25, 2016 requesting approval of Medical Staff Credentialing Action Items as follows:

<u>Appointments:</u>
Nguyen, Christopher, MD; Koo, Ralph, MD; Nair, Lakshmi, MD

<u>Temporary Privileges:</u>
Koo, Ralph, MD

<u>Reappointments:</u>
Bhatti, Naveenpal, MD; Bodnar, Shelli, MD; Chan, Steven, DDS; Cheney, Tamara, MD; Cohn, James, MD; Da Roza, Ricardo, MD; Dudyala, Vijaya, MD; Hadiwidjaja, Angeline, MD; Hogberg, Ingrid, MD; Jain, Ashit, MD; Japra, Romesh, MD; Kahlon, Vasdeep, MD; Kumar, Mrudula, MD; Lilja, James, MD; Lou, Lay-Hwa, MD; Maish, Mary, MD; Medhekar, Vaibhav, MD; Naimi, Nasrin, MD; Nicholson, Williams, MD; Quiroz, Eva, MD; Reen, Ranjit, MD; Sanrda-Maduro, Mary Ann, MD; Shibuya, Barry, MD; Shih, Chuanfang, MD; Sing, Devindar, MD; Taylor, Claribel, MD; Wong, Clifford, MD; Zheng, Hui, MD

<u>Transfer in Staff Category:</u>
Chan, Steven, DDS; Hogberg, Ingrid, MD; Miller, Rachel, PA-C; Bodnar, Shelli, MD; Cohn, James, MD; Da Roza, Ricardo, MD

<u>Completion of Proctoring & Advancement in Staff Category:</u>
Miller, Rachel, PA-C

<u>Completion of Proctoring Prior to Eligibility for Advancement in Staff Category</u>
Ravid, Noga, MD

<u>Delete Privilege Requests:</u>
Bodnar, Shelli, MD; Chan, Steven, DDS; Maish, May, MD; Hogberg, Ingrid, MD; Singh, Devindar, MD; Cohn, James, MD; Da Roza, Richardo, MD; Dudyala, Vijaya, MD; Medhekar, Vaibhav, MD; Japra, ROmesh, MD: Reen, Ranjeet, MD; Lou, Lay-Hwa, MD; Shibuya, Barry, MD; Shih, Chuanfang, MD; Wong, Clifford, MD;

Naimi, Nasrin, MD; Jain, Ash, MD; Nichoslon, William, MD

Resignations:
Cayetano, Jacqueline, PA-C

Director Stewart moved for approval of the credentialing action items presented by Dr. Achanta.

Director Danielson seconded the motion.
Roll call was taken:

Michael Wallace – aye
William Nicholson, MD - abstain
Patricia Danielson, RHIT – aye
Bernard Stewart, DDS - aye
Jacob Eapen, MD - aye

The motion carried.

SERVICE LEAGUE REPORT

Debbie Jackson, Service League President presented the Service League Report. Ms. Jackson shared that the Service League held its 61st Annual Meeting on February 9, 2016 in the Anderson Auditorium. The membership conducted it yearly meeting with adult volunteers in attendance. During the meeting a moment of silence was observed for volunteers who had passed away during the year and our Charter/Honorary member Laura Pessagno was recognized as well as Past Presidents and New Volunteers. A luncheon was served to the membership and guests followed by guest speakers CEO Nancy Farber, Dr. Achanta, Dr. Nicholson, Dr. Stewart and Pat Danielson. The Service League presented the hospital gift to Nancy Farber in the amount of $60,000, which will be going toward the new hospice room dedicated in the memory of Jim Stone. The volunteers were recognized for their years of service with a pin presented by Nancy Farber and Angus Cochran.

MEDICAL STAFF REPORT

Dr. Kranthi Achanta reported there are 559 Medical Staff members.

HOSPITAL CALENDAR: Community Outreach

The Hospital Calendar video highlighted the following events:

Past Health Promotions & Outreach Events

During January and February Lucy Hernandez, Community Outreach Project Manager, presented 12 hand hygiene classes for students at Brier Elementary, Cabrillo Elementary, Chadborne Elementary, and Glenmoor Elementary schools all located in Fremont. Information was provided on proper hand washing and hygiene to prevent infection and the spread of germs; 313 students attended.

On Thursday, January 21st, as part of the Women Empowering Women series, Dr. Victoria Leiphart, gynecologist, presented "Setting Goals"; 14 people attended.

On Friday, January 22nd, Lincoln Elementary School in Newark held its second health fair for students, teachers and parents.
Washington Hospital Staff provided health information on proper hand washing and hygiene to prevent infection and the spread of germs; over 350 people attended

On Thursday, January 28th, Michelle Hedding, R.N., Spiritual Care Coordinator, presented "It's Your Choice" which featured advance care planning to the Rotary Club of Niles; 75 people attended.

On Tuesday, February 2nd, as part of the Stroke Education Series, Melissa Reyes, R.N., presented "Living with Stroke" and "Future Diagnosis and Management"; 17 people attended.

On Wednesday, February 3rd, as part of the Washington Sports Medicine and Washington Outpatient Rehab Center bimonthly education series, Dr. Steven Zonner, family practice, and Sharmi Mukherjee, physical therapist, presented "Exercise Injuries: Prevention and Treatment"; 28 people attended

On Thursday, February 4th, as part of the Diabetes Matters Series, Dr. Archana Bindra, endocrinologist, presented "Insulin Delivery: To Pump or Not to Pump"; 10 people attended

Upcoming Health Promotions & Community Outreach Events

On Thursday, February 11th from 6:00 to 8:00 p.m., Dr. Victoria Leiphart, gynecologist, will be presenting "Menopause: A Mind-Body Connection Approach".

On Saturday, February 13th from 1:30 to 3:30 p.m. the Washington Hospital Bioethics Committee will present a screening of the Frontline presentation of Dr. Atul Gawande's "Being Mortal" video at the Niles Discovery Church.

"Being Mortal" offers an exploration of aging, death, medicine, and contributes to the knowledge and understanding of advance health care planning. Father Jeff Finley, Palliative Care Coordinator, will facilitate a questions and answers session following the screening.

On Tuesday, February 23rd from 1:00 to 3:00 p.m., Dr. Gabriel Herscu, vascular surgeon, will be presenting "Not a Superficial Problem: Varicose Veins and Chronic Venous Disease".

On Tuesday, March 1st from 1:00 to 3:00 p.m., Dr. Dale Amanda Tylor, otolaryngologist , and Dr. Charan Singh, neurologist, will present "Vertigo and Dizziness: What You Need to Know"

On Tuesday, March 8th from 1:00 to 3:00 p.m., Shelja Bansal, physical therapist, will be presenting "Balance and Falls Prevention."
On Tuesday, March 15th from 6:00 to 8:00 p.m., obstetrician/gynecologists Dr. Alison Slack and Dr. Stacie Macdonald along with Dr. Mark Saleh urologist, will be presenting "Urinary Incontinence in Women: What You Need to Know."

On Tuesday, March 15th from 6:00 to 8:00 p.m., Dr. Harman Chawla, internal medicine, will present "Cognitive Assessment as You Age."

Washington Hospital Healthcare Foundation Report

HOSPITAL CALENDAR: Washington Hospital Foundation Report

On January 25, the Foundation held its annual meeting for trustees and members. At the meeting, trustees elected Sondra De Barr, Dr. Jan Henstorf, and Skip Turner to join the board of trustees. Helen Kennedy was elected to serve as President-Elect of the Foundation.

At the annual meeting, trustees granted over $433,000 to support a wide variety of clinical services at Washington Hospital, including surgical services, the Community Mammography Program, diabetes education, Washington Special Care Nursery, and the intensive care unit.

Washington Hospital Healthcare Foundation is proud to announce that it will host the 31st Annual Golf Tournament at Castlewood Country Club on Monday, April 25, 2016. Held in memory of long-time Fremont businessman, Gene Angelo Pessagno, the tournament promises a day of great golf and fun surprises.

The Washington Township Healthcare District Board of Directors Report

HOSPITAL CALENDAR: The Washington Township Healthcare District Board of Directors Report

Washington Township Healthcare District Board Members attended the Rotary Club of Newark's 34th Annual Crab and Pasta Dinner on January 23rd.

Washington On Wheels Mobile Health Clinic, W.O.W.

HOSPITAL CALENDAR: Washington On Wheels Mobile Health Van

During the month of January, the Washington On Wheels Mobile Health Clinic (W.O.W.) continued to serve community members at the Fremont Family Resource Center, the Fremont Senior Center, and the Ruggieri Senior Center in Union City and Brier Elementary School in Fremont.

The total number of community members receiving healthcare at the Washington On Wheels Clinic during the month of January was 27.

Internet Marketing

HOSPITAL CALENDAR: Internet Report

There were over 32,231 visits to the hospital website in the month of January. The hospital's Employment section was the most viewed webpage with 13,266 page views, followed by the Physician Finder with 9,685 page views. The About WHHS section with 9,259 page views, the Volunteers section had 4,406 page views and the Women's Health and Pregnancy section had 2,139 page views.

InHealth - Channel 78

HOSPITAL CALENDAR: InHealth

During the month of January, Washington Hospital's cable channel 78, InHealth, captured a Diabetes Matters program called "Ready, Set, Goal Setting!"
In addition, InHealth aired the January Board of Directors meeting; two Diabetes Matters programs called "Gastroparesis" and "Strategies for Physical Activities with Diabetes"; three Health and Wellness programs titled "Preventative Screening for Adults", "Future Planning and Advance Health Care Directives" and "Prostate Cancer"; and three Caregiver Series programs named "Managing Family Dynamics", "Estate Planning" and the "Panel Discussion."

Awards and Recognitions

HOSPITAL CALENDAR: Awards and

The Outstanding Achievement Award (OAA) from the American College of Surgeon's Commission on Cancer (CoC) recognizes cancer programs that

Recognitions

demonstrate excellence by earning commendation for all applicable standards and providing quality care to patients with cancer. Washington Hospital earned the OAA by completing the accreditation survey and receiving a Performance Report that indicated an accreditation award of "Three-Year with Commendation" outlining the commendation ratings for the seven commendation-level standards and no deficiencies. Of the Hospital's undergoing the survey in 2015 Washington Hospital is one of two to have this distinction three surveys in a row. Washington Hospital's Community Cancer Program includes screening and early detection programs, surgical oncology, medical oncology, tumor board, tumor registry, clinical research, oncology nursing, social services, support services and the Washington Radiation Oncology Center.

The City of Fremont awarded a certificate of appreciation to Washington Hospital in recognition for its commitment to the environment through the Hospital's Composting for Business food scrap recycling program.   Most of the food scraps from the Hospital are produced during the preparation of food in the cafeteria.

HOSPITAL CALENDAR: Additional Events

<u>Additional Events</u>

Washington Hospital and UCSF Benioff Children's Hospital have teamed-up and are the official sponsors of the new Children's Play Area at Newpark Mall in Newark. The 1091 square foot area provides a indoor space for children to play, learn and have fun. The play area promotes the development of motor skills and confidence by allowing children to climb on the surfboard and ride a wave, or slide down the waterfall in Little Yosimte, or simply crawl or play in the camp tent- all in a controlled environment. The play area is ADA compliant and the structures have a soft coating that is tested and certified antibacterial.

HOSPITAL CALENDAR: Employee of the Month – Aimee Stauffer

<u>Employee of the Month</u>

Aimee Stauffer joined Washington Hospital in 2010 as a Business Assistant for Rehab Services. Today, Aimee continues in her role with Rehab Services, but has also taken on more responsibilities within the department and in other areas of the Hospital. Attention to detail and meticulous records are some of Aimee's strengths that are valued and appreciated by her colleagues. In addition to her responsibilities as a Business Assistant, Aimee is also an active member of WHEA and currently serves as secretary. Aimee is a native of the Bay Area and went to school locally. She has a Human Development Associates Degree from Ohlone College. Sharks fan.

LEAN/KAIZEN REPORT

Nancy Farber, Chief Executive Officer introduced Kranthi Achanta, Chief of Staff and Bettina Kurkjian, MD. Dr. Achanta and Dr. Kurkjian presented the Lean Physician Journey. From the beginning at WHHS, physicians have been included in our Lean journey. This includes: training, certification process, improvement workshops, and most recently, the Kaizen promotion office. Many aspects of the Lean philosophy and tools align well with physician practices and goals. Dr. Achanta and Dr. Kurkjian continued by sharing photos of the ER Treatment Bay and discussed a collaborative approach: involving all the people who are doing the work - together we define the problem and devise solutions.

CONSTRUCTION REPORT
Construction Update

Nancy Farber, Chief Executive Officer introduced Ed Fayen, Senior Associate Administrator. Mr. Fayen presented the construction update on the parking garage and the Morris Hyman Critical Care Pavilion. Mr. Fayen shared photos of the lighting that is now operational on the ground level, fire pump equipment, electrical equipment room, and the installation of stair #1. Mr. Fayen also shared photos of the foaming tunnel wall and corbels at the North East corner of the Morris Hyman Critical Care Pavilion, the attaching of the cantilever steel, as well as a photo of the South East corner structure, moat wall, and corbel. Mr. Fayen also shared a photo of the site view as of January 29, 2016.

QUALITY REPORT: Infection Prevention Update

Mary Bowron, Senior Director of Quality and Resource Management presented the Infection Prevention Update and shared why infection prevention should be regulated as well as information on Washington Hospital's Infection Prevention Committee. Ms. Bowron continued by sharing the key components of the infection prevention program, data reporting and the current process for infection prevention. Washington Hospital's Infection Prevention Risk Management is an annual hospital-wide risk assessment performed by a program coordinator and consultant. The purpose of this is to evaluate potential risk of infection, contamination and exposure. Ms. Bowron reported on hand hygiene compliance, surveillance of elements of infection prevention, surveillance of environmental services, employee health and safety, evidence-based practice, patient education, community health.

FINANCE REPORT

Chris Henry, Chief Financial Officer, presented the Finance Report for December 2015. The average daily census was 166.1 with admissions of 1,056 resulting in 5,149 patient days. Outpatient observation equivalent days were 224. The average length of stay was 4.91 days. The case mix index was 1.532. Deliveries were 160. Surgical cases were 361. Joint Replacement cases were 140. Neurosurgical cases were 16. Cardiac Surgical cases were 6. The Outpatient visits were 6,740 and Emergency visits were 4,425. Total productive FTEs were 1,234.1. FTEs per adjusted occupied bed were 6.43.

HOSPITAL OPERATIONS REPORT

Ms. Farber presented the Hospital Operations Report for January. There were 1,098 patient admissions with an average daily census of 182. Preliminary information indicated inpatient revenue for the month of January at approximately $180,800,000. There were 147 deliveries in the Hospital resulting in 340 baby days. There were 359 surgical cases at the Hospital and 354 Cath Lab procedures. The Emergency Room saw 4,663patients. The clinics saw approximately 3,605 patients. FTEs per Adjusted Occupied Bed were 5.9.

APPROVAL OF APPOINTMENT OF DEVELOPMENT CORPORATION BOARD MEMBER

Director Eapen moved for appointment of Gloria Fuerniss to fill the vacant seat on the Board of Directors of the Washington Township Hospital Development Corporation to fulfill its five member capacity.

Director Stewart seconded the motion.
Roll call was taken:

Michael Wallace – aye
William Nicholson, MD - aye

Patricia Danielson, RHIT – aye
Bernard Stewart, DDS - aye
Jacob Eapen, MD - aye

The motion unanimously carried.

APPROVAL OF VEIN ILLUMINATOR

In accordance with District Law, Policies and Procedures, Director Eapen moved the Chief Executive Officer be authorized to proceed with the purchase of seven Accuvein Vein Illuminators in the amount not to exceed $38,000. This item was approved in the FY16 Capital Asset Budget.

Director Stewart seconded the motion.
Roll call was taken:

Michael Wallace – aye
William Nicholson, MD - aye
Patricia Danielson, RHIT – aye
Bernard Stewart, DDS - aye
Jacob Eapen, MD - aye

The motion unanimously carried.

APPROVAL OF SCN WARMERS

In accordance with District Law, Policies and Procedures, Director Eapen moved the Chief Executive Officer be authorized to proceed with the purchase of two new warmers and upgraded parts for three additional warmers in an amount not to exceed $54,027. This purchase was not included in the FY 16 Fixed Asset Capital Budget; the Foundation is donating funds raised at the 2014 Top Hat event to cover this purchase.

Director Stewart seconded the motion.
Roll call was taken:

Michael Wallace – aye
William Nicholson, MD - aye
Patricia Danielson, RHIT – aye
Bernard Stewart, DDS - aye
Jacob Eapen, MD - aye

The motion unanimously carried.

APPROVAL OF REPLACEMENT OF HOSPITAL NETWORK

In accordance with District Law, Policies and Procedures, Director Eapen moved the Chief Executive Officer be authorized to enter into the necessary contracts and proceed with the purchase of the hardware, software and implementation services for the local area network/wireless upgrade project for a total amount not to exceed $4,032,860. This is an approved project in the 2016 Capital budget.

Director Stewart seconded the motion.
Roll call was taken:

Michael Wallace – aye
William Nicholson, MD - aye
Patricia Danielson, RHIT – aye

Bernard Stewart, DDS - aye
Jacob Eapen, MD - aye

The motion unanimously carried.

APPROVAL OF EPIC CARE LINK

In accordance with District Law, Policies and Procedures, Director Eapen moved the Chief Executive Officer be authorized to enter into the necessary contracts and proceed with the purchase of the hardware, software and implementation services for Epic WeLink Project for a total amount not to exceed $248,138. This is an approved project in the 2016 Capital budget.

Director Stewart seconded the motion.
Roll call was taken:

Michael Wallace – aye
William Nicholson, MD - aye
Patricia Danielson, RHIT – aye
Bernard Stewart, DDS - aye
Jacob Eapen, MD - aye

The motion unanimously carried.

ADJOURN TO CLOSED SESSION

In accordance with Health & Safety Code Sections 1461, 1462, and 32106 and Government Code Section 54954.6(h). Director Wallace adjourned the meeting to closed section at 8:28p.m. as the discussion pertained to Hospital trade secrets, human resources matters and risk management.

RECONVENE TO OPEN SESSION & REPORT ON CLOSED SESSION

Director Wallace reconvened the meeting to open session at 8:50p.m. and reported no action was taken in closed session.

ADJOURNMENT

There being no further business, Director Wallace adjourned the meeting at 8:51pm.

Michael Wallace	Patricia Danielson, RHIT
President	Secretary

A meeting of the Board of Directors of the Washington Township Health Care District was held on Monday, February 22, 2016 in the Boardroom, Washington Hospital, 2000 Mowry Avenue, Fremont, California. Director Nicholson called the meeting to order at 7:30 a.m.

CALL TO ORDER

Roll call was taken. Directors present: William Nicholson, MD; Bernard Stewart, DDS; Patricia Danielson, RHIT; Jacob Eapen, MD
Excused: Michael Wallace

ROLL CALL

Also present: Kranthi Achanta, MD; Timothy Tsoi, MD; Jan Henstorf, MD; Peter Lunny, MD; Stephanie Williams, Associate Administrator; Albert Brooks, MD

There were no oral or written communications.

COMMUNICATIONS

Director Nichoslon adjourned the meeting to closed session at 7:30 a.m. as the discussion pertained to Medical Audit and Quality Assurance Matters pursuant to Health & Safety Code Sections 1461 and 32155.

ADJOURN TO CLOSED SESSION

Director Nicholson reconvened the meeting to open session at 8:40 a.m. and reported no reportable action was taken in closed session.

RECONVENE TO OPEN SESSION & REPORT ON CLOSED SESSION

There being no further business, the meeting was adjourned at 8:40 a.m.

ADJOURNMENT

Michael Wallace President	Patricia Danielson, RHIT Secretary

A meeting of the Board of Directors of the Washington Township Health Care District was held on Monday, February 24, 2016 in the Boardroom, 2000 Mowry Avenue, Fremont, California. Director Nicholson called the meeting to order at 6:01 p.m. and led those present in the Pledge of Allegiance.

CALL TO ORDER

Roll call was taken. Directors present: William Nicholson, MD; Bernard Stewart, DDS; Patricia Danielson, RHIT; Jacob Eapen, MD
Excused: Michael Wallace

ROLL CALL

Also present: Nancy Farber, Chief Executive Officer; Kimberly Hartz, Senior Associate Administrator; Bryant Welch, Associate Administrator, Tina Nunez, Associate Administrator, Chris Henry, Associate Administrator; Christine Flores, District Clerk; John Lee, Chief Information Officer; Paul Kozachenko

COMMUNICATIONS

There were no oral communications.

There were no written communications.

ADJOURN TO CLOSED SESSION

In accordance with Health & Safety Code Sections 1461, 1462 and 32106 and Government Section 54954.5(h) Director Nicholson adjourned the meeting to closed session at 6:01 p.m., as the discussion pertained to Hospital trade secrets, Human Resources matters and Risk Management.

RECONVENE TO OPEN SESSION & REPORT ON CLOSED SESSION

Director Nicholson reconvened the meeting to open session at 6:44 p.m. and reported no reportable action was taken in closed session.

CONSIDERATION OF CLAIM: QUIAMBAO

In accordance with District Law, Policies and Procedures, Director Eapen moved for the denial of the claim received on February 1, 2016 on behalf of Lorinda Quiambao and that the Chief Executive Officer be directed to provide notice in accordance with government code section 945.6.

Director Stewart seconded the motion.

Roll call was taken:

Michael Wallace - away
William Nicholson, MD - abstained
Bernard Stewart, DDS - aye
Patricia Danielson, RHIT – aye
Jacob Eapen, MD - aye

The motion carried.

ADJOURNMENT

There being no further business, Director Nicholson adjourned the meeting at 6:46pm.

Michael Wallace President	Patricia Danielson, RHIT Secretary

CALL TO ORDER

A meeting of the Board of Directors of the Washington Township Health Care District was held on Monday, February 29, 2016 in the Boardroom, 2000 Mowry Avenue, Fremont, California. Director Wallace called the meeting to order at 6:03 p.m. and led those present in the Pledge of Allegiance.

ROLL CALL

Roll call was taken. Directors present: Michael Wallace, William Nicholson, MD; Bernard Stewart, DDS; Patricia Danielson, RHIT; Jacob Eapen, MD

Also present: Nancy Farber, Chief Executive Officer; Kimberly Hartz, Senior Associate Administrator; Bryant Welch, Associate Administrator, Tina Nunez, Associate Administrator, Chris Henry, Associate Administrator; Christine Flores, District Clerk; Neil Marks, Rocke Blair, Bill Coleman, Hayden Gallary, and Steve Foresti.

COMMUNICATIONS

There were no oral communications.

There were no written communications.

ADJOURN TO CLOSED SESSION

In accordance with Health & Safety Code Sections 1461, 1462 and 32106 and Government Section 54954.5(h) Director Wallace adjourned the meeting to closed session at 6:04 p.m., as the discussion pertained to Hospital trade secrets, Human Resources matters and Risk Management.

RECONVENE TO OPEN SESSION & REPORT ON CLOSED SESSION

Director Wallace reconvened the meeting to open session at 7:39 p.m. and reported no reportable action was taken in closed session.

ADJOURNMENT

There being no further business, Director Danielson adjourned the meeting at 7:40pm.

Michael Wallace President	Patricia Danielson, RHIT Secretary

INTENSIVISTS DIRECTED CRITICAL CARE MODEL

SUMMARY

Washington Hospital Healthcare System
SINCE 1948

Memorandum

DATE: March 4, 2016

TO: Board of Directors, Washington Township Health Care District

FROM: Nancy Farber, Chief Executive Officer

SUBJECT: Receive and Consider Information regarding Transition to Intensivist Directed Critical Care Model

Introduction

In 2008 Washington Township Health Care District implemented an intensivist program in the ICU/CCU, where contracted intensivists are available 24/7 on site, to provide care for unassigned patients or for patients upon request by their physician, while in the ICU/CCU. Since the program was implemented the quality of care in the ICU/CCU has shown significant improvement directly attributable to the Intensivist program. Therefore, in order to continue to improve the quality of care for the patients in the community who require admission to the ICU/CCU, it is recommended that an Intensivist Directed Critical Care Model be implemented for all patients in Washington Hospital's ICU/CCU.

As part of this proposal, management recommends that at the March 9, 2016 meeting, the Board receive and consider this memo and the other written materials provided to the Board related to this issue and also receive input from members of staff and/or the public who wish to speak on this issue. Management recommends that the Board not take formal action tonight on adoption of the Intensivist Directed Critical Care Model.

Prior to the next Board meeting, Management intends to bring this item before the Medical Executive Committee with the goal of bringing this back to this Board for formal adoption at the April 13, 2016 Board meeting.

Background

Intensivists are physicians who specialize in the care of critically ill patients and who direct and provide critical care in an intensive care unit (ICU). Critical Care is an evolving medical specialty. Its creation and development are based on evidence showing its beneficial role. The appropriate care of the critically ill requires knowledge of complex multiple organ interactions and dysfunctions, and readiness to assimilate numerous patient-related data to guide timely treatment and evidence based practice guidelines. The Intensivist, as opposed to the single-organ specialist, is therefore better equipped to provide leadership in the management of the critically ill patient.

Peer-reviewed articles have demonstrated that Intensivist directed care has shown:

- A reduction in ICU mortality and morbidity[1-4,9,11,12]
- A reduction in hospital mortality[1-6,10,13]
- A decrease in days that patients are on a mechanical ventilator[7, 8]
- A reduced length of stay[1-3, 7-10,13]
- An improvement in staff satisfaction[9]
- An improvement in staff knowledge of critical care[10]

In addition, Washington Hospital's own data show quality improvements since the Intensivist program was established in 2008. For example:

- The overall rating of our ICU/CCU (as classified by the Society of Critical Care Medicine) has improved since the Intensivist model was implemented at Washington Hospital;
- Early feeding and mobility initiatives implemented by the Intensivists were contributing factors in helping to decrease the prevalence of hospital acquired pressure ulcers;
- The readmission rate to the ICU/CCU, within the same hospital visit, for Non-Intensivists directed patients was higher than the rate for Intensivists directed patients.
- There has been a decrease in the duration of time the average ICU/CCU patient is on a ventilator since the start of the Intensivist program (2008), with this decrease sustained through CY 2015.
- With the establishment of the Intensivist program, there has been an increased focus on sepsis awareness and management, with a decrease in severe sepsis mortality rate over time.
- A comparison of ICU patients with Intensivist involvement to ICU/CCU patients with no (documented) Intensivist involvement, demonstrated that a greater proportion of Intensivists' patients have discussions with their care team, compared to non-Intensivists' patients. Patients who have these discussions are involved in critical care decisions, resulting in a change of code status allowing for palliative care if needed.
- If the total Non-Intensivist ICU/CCU days had the Intensivist Case Mix Index Adjusted Average Direct Cost per ICU Day, the Healthcare System could have potentially realized a substantial cost savings related to the total ICU/CCU days.

Before the advent of the Intensivist program at Washington Hospital, patients often had to wait to be seen by their attending physician, resulting in potential delays in patient care and longer lengths of stay in the ICU/CCU. The 24/7/365 coverage in the ICU/CCU by Intensivists since 2008 has eliminated this delay issue in many instances. In addition, coverage by Intensivists in the ICU/CCU helps to accommodate improved patient flow between the Emergency Department and the medical/surgical units in the Hospital and the ICU/CCU. However, at this time the Intensivists only manage about 32% of the ICU/CCU cases and 46% of the ICU/CCU patient days.

Definition of a Intensivist Directed Critical Care Model

Literature shows that patient care in the ICU is best provided by an integrated team of dedicated experts directed by a trained and present physician credentialed in critical care medicine (an Intensivist). The team may consist of critical care nurses, intensivists, nurse practitioners, pharmacists, physician assistants, physician specialists, primary care physicians, respiratory therapists, other professionals, and patients and their families.

In the past, many ICUs used a model in which patients were cared for by their primary care physician and specialists as required. However, over the last two decades, the positive impact of a qualified Intensivist on the outcome of ICU patients became recognized and many hospitals adopted some degree of a high-intensity or Intensivist directed care model in which patients' care is directed exclusively by an Intensivist and all other physicians act as a consultant including the primary care physician.

An analysis of Bay Area hospitals has shown that an Intensivist Directed Critical Care Model for the ICU and CCU has become a standard practice as a number of other hospitals have decided to transition to this model. Our research has shown the following organizations have made this transition:

- Eden Medical Center
- Stanford Medical-ICU
- Alta Bates – Alta Bates Campus
- Alta Bates – Summit Campus
- Santa Clara Valley Medical Center
- Kaiser Santa Clara
- Kaiser San Francisco
- UCSF
- John Muir

Proposed Changes

Given the aforementioned benefits of the Intensivist Directed Critical Care model and Washington Hospital's commitment to the Patient First Ethic, Washington Township Health Care District is proposing an Intensivist Directed Critical Care Model where all patients are admitted to the ICU/CCU by the Intensivist and the Intensivist oversees and directs the care of the patient. Currently, the majority of physicians on staff at Washington Hospital Healthcare System are able to admit patients to the ICU/CCU and provide direct medical care to patients as either the Attending physician or Consulting physician.

Under the proposed model, only the Intensivist is able to admit patients to the ICU/CCU and the Intensivist will be the Attending of record while the patient is in the ICU/CCU. As the Attending of record, the Intensivist has final approval on all orders. All other physicians with the appropriate privileges will be allowed to consult in their areas of expertise as needed. They can write orders in consultation with the Intensivist but the Intensivist will have final approval on all orders.

Next Steps

1. Management will discuss the Intensivist Directed Critical Care Model with the Medical Executive Committee at the Medical Executive Committee's next meeting.
2. Management will present the Intensivist Directed Critical Care Model to the Board for formal approval at its April 13, 2016 meeting. At that meeting, the Board will receive input from the Medical Executive Committee and additional written and oral testimony.

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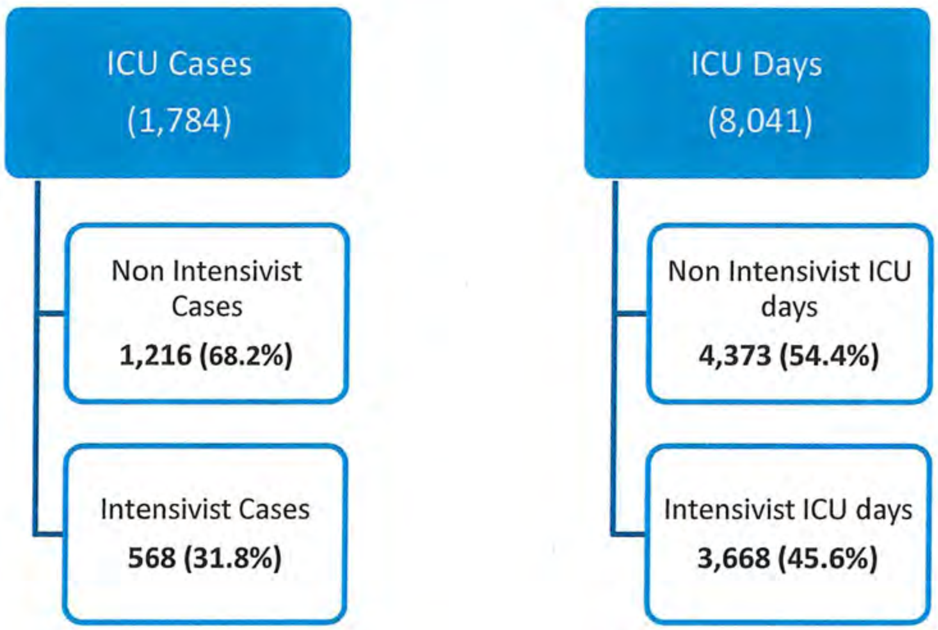
WHHS DATA

WASHINGTON TOWNSHIP HEALTH CARE DISTRICT

CCU/ICU PRIVILEGE QUALIFICATIONS: WHHS DATA

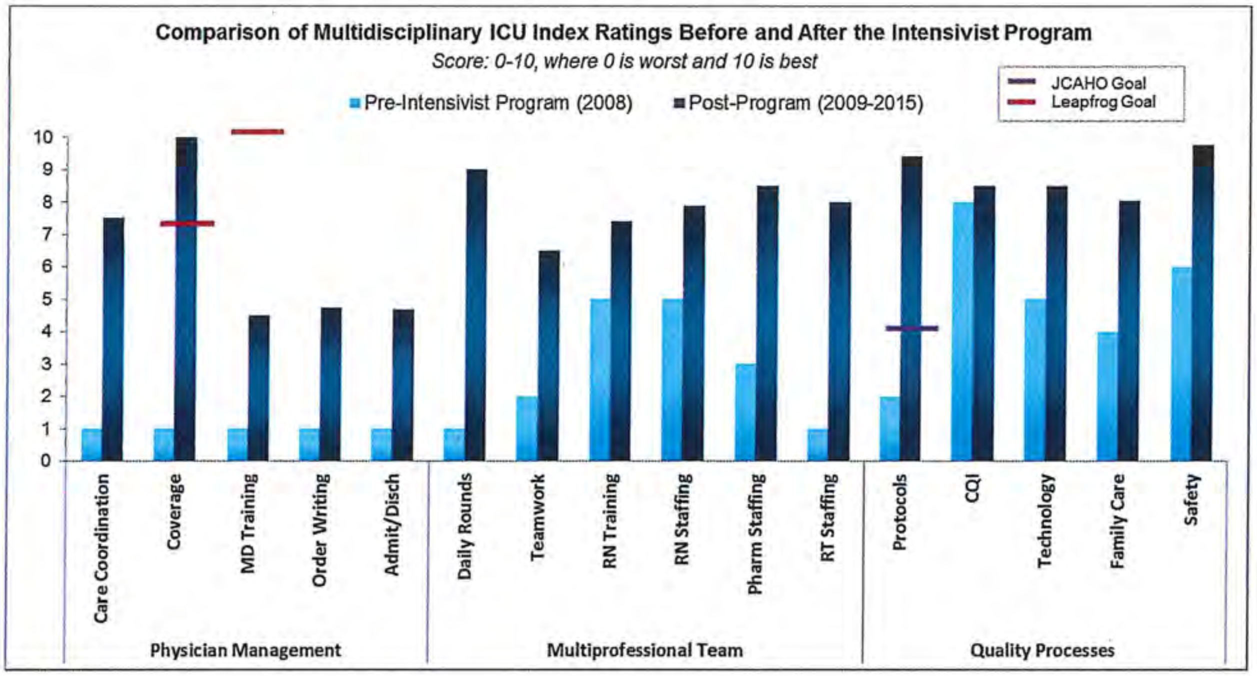
Volume Summary (CY15)



Quality Benefits of a Closed-ICU Approach

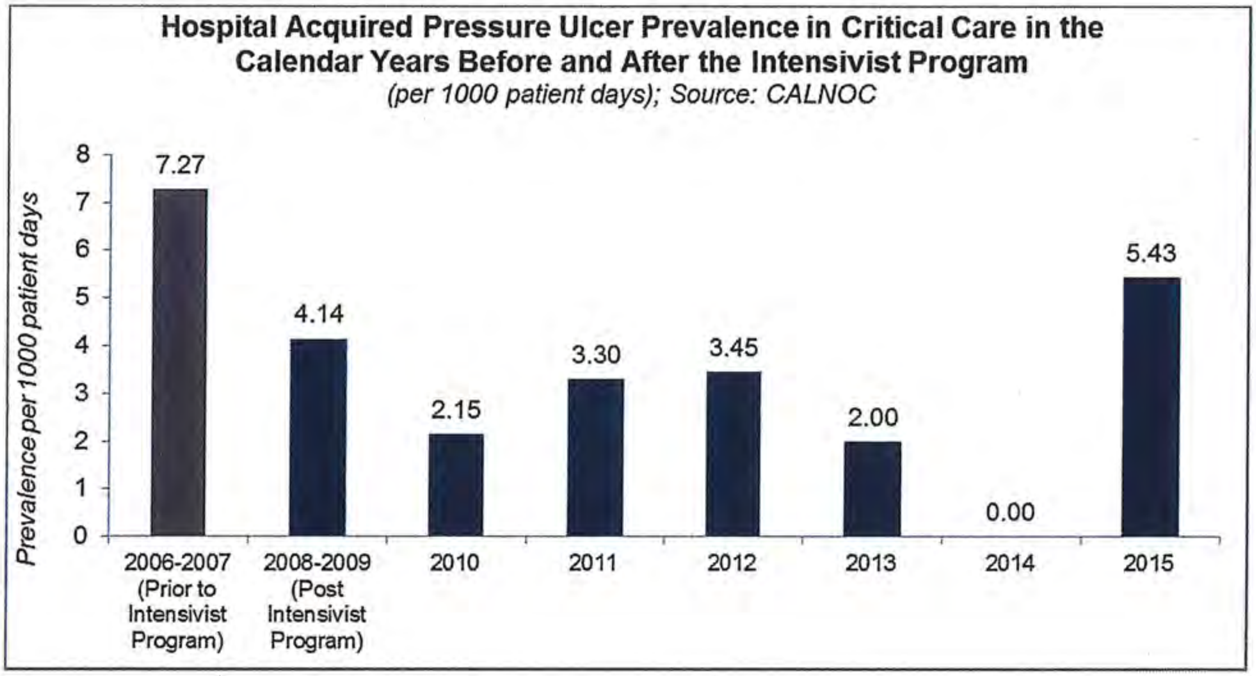
In addition to the financial data, staff also reviewed quality data related to the ICU and the Intensivist program and identified the following meaningful indicators:

1. *The overall rating of our ICU (as classified by the Society of Critical Care Medicine) has improved since the Intensivist model was implemented at Washington Hospital Healthcare System in 2008.*



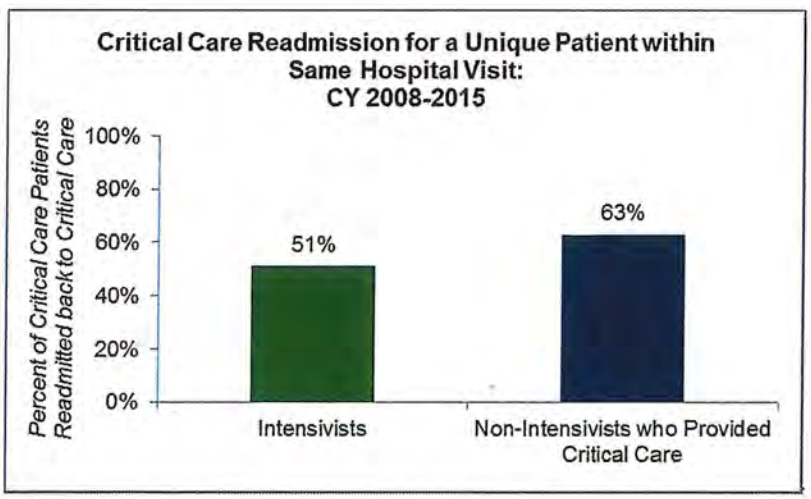
Note: 'MD Training' and 'Order Writing' are influenced by an Intensivist Directed Critical Care Model vs.an Open ICU and we expect to see an improvement in rating with an Intensivist Directed Critical Care Model.

2. *The prevalence of hospital acquired pressure ulcers decreased after introducing the Intensivist program*



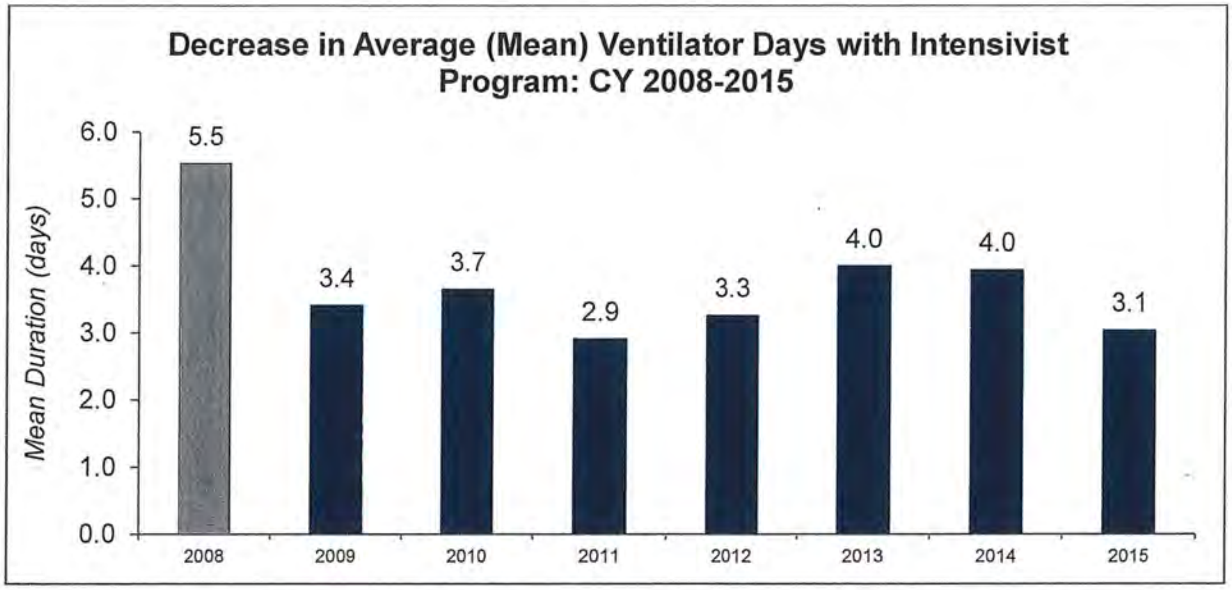
Source: CALNOC: Collaborative Alliance for Nursing Outcomes

3. *Since the start of the Intensivist program in 2008, Non-Intensivists had more patients who were discharged and then readmitted to the ICU, within the same hospital visit, compared to Intensivists.*

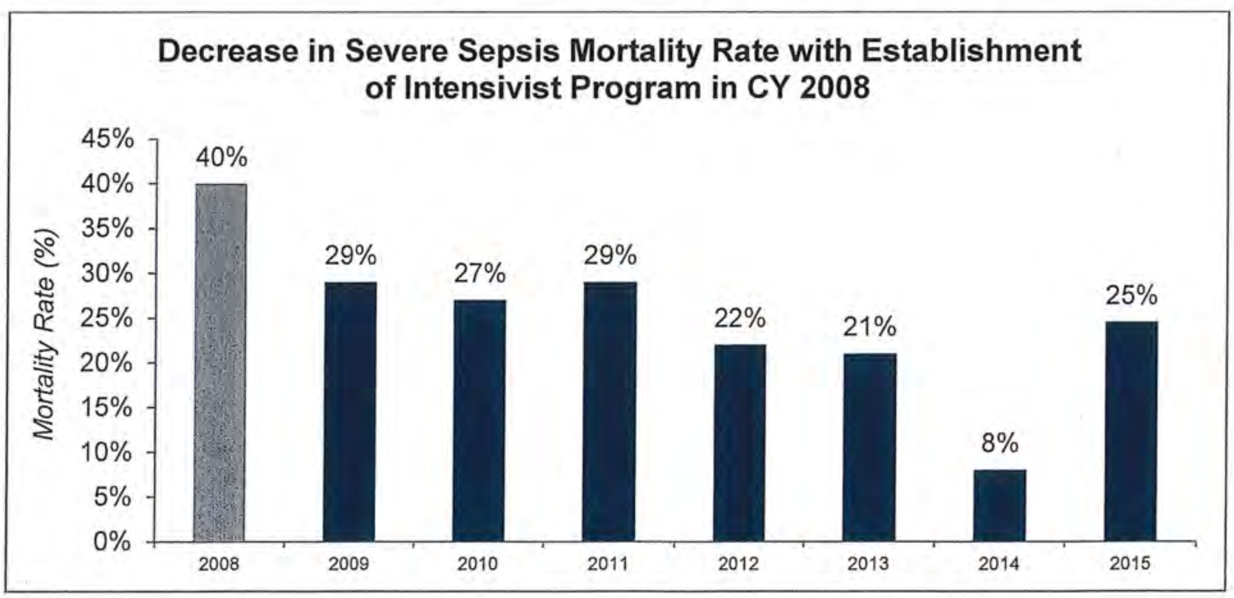


Note: This data reflects patients for which intensivists were admitting physicians and does not include critical care patients with an Intensivist consultation.

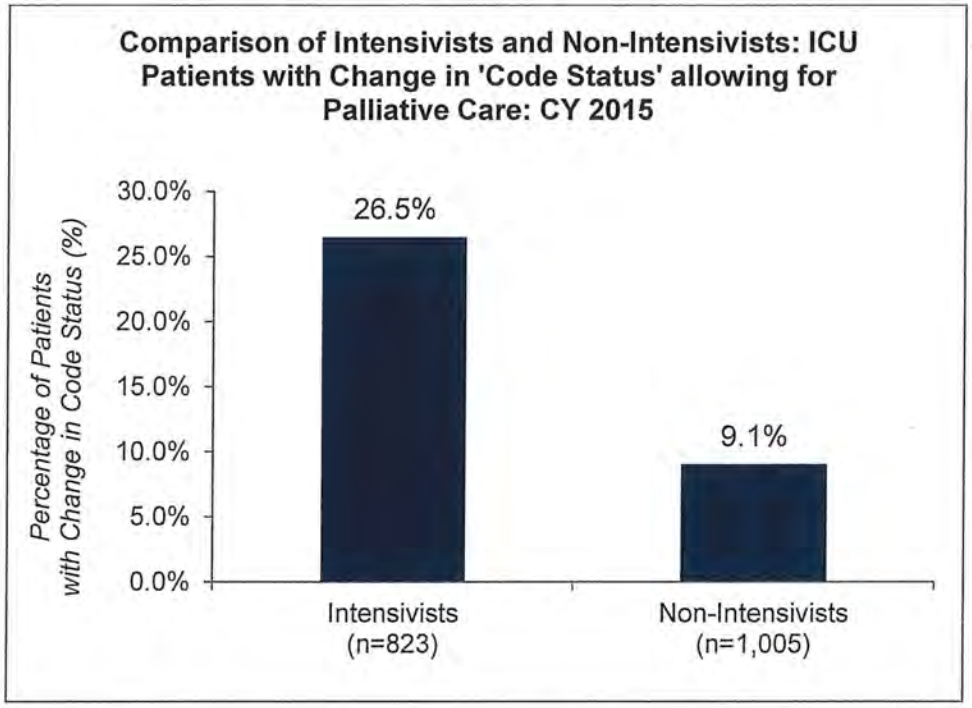
4. *There has been a decrease in the duration of time the average ICU patient is on a ventilator since the start of the Intensivist program (2008), with this decrease sustained through CY 2015.*



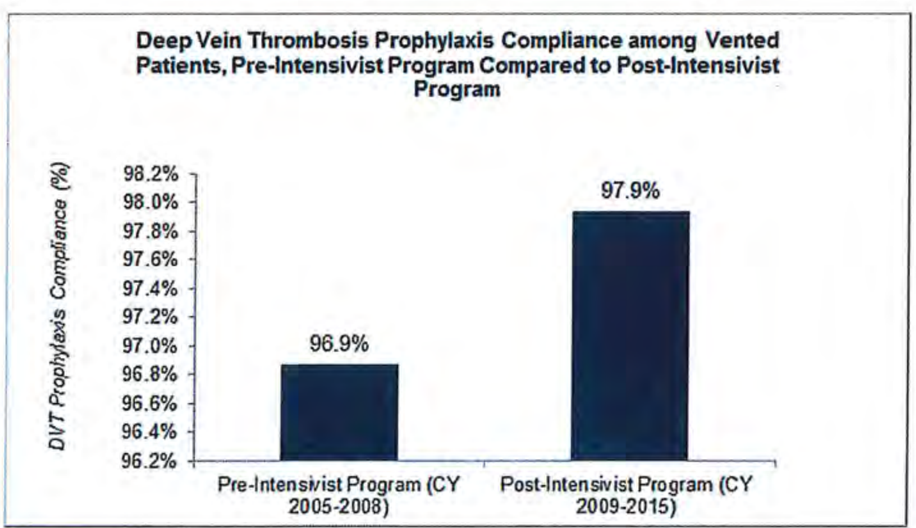
5. *With the establishment of the Intensivist program, there has been an increased focus on sepsis awareness and management, with a decrease in severe sepsis mortality rate over time.*



6. *A comparison of ICU patients with Intensivist involvement to ICU patients with no (documented) Intensivist involvement, demonstrated that a greater proportion of Intensivists' patients have discussions with their care team, compared to non-Intensivists' patients. Patients who have these discussions are involved in critical care decisions, resulting in a change of code status allowing for palliative care if needed.*



7. *With the establishment of the Intensivist program, deep vein thrombosis prophylaxis compliance among vented patient increased compared to a three year period before the implementation of the Intensivist program.*



REF 1: AHRQ

Chapter 38. "Closed" Intensive Care Units and Other Models of Care for Critically Ill Patients

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Background

Patients in the intensive care unit (ICU) require complex care relating to a broad range of acute illnesses and pre-existing conditions. The innate complexity of the ICU makes organizational structuring of care an attractive quality measure and a target for performance improvement strategies. In other words, organizational features relating to medical and nursing leadership, communication and collaboration among providers, and approaches to problem-solving[1] may capture the quality of ICU care more comprehensively than do practices related to specific processes of care.[2]

Most features of ICU organization do not exert a demonstrable impact on clinical outcomes such as morbidity and mortality.[3] While hard clinical outcomes may not represent the most appropriate measure of success for many organizational features, the role of "intensivists" (specialists in critical care medicine) in managing ICU patients has shown a beneficial impact on patient outcomes in a number of studies. For this reason, the Leapfrog Group, representing Fortune 500 corporations and other large health care purchasers, has identified staffing ICUs with intensivists as one of three recommended hospital safety initiatives for its 2000 purchasing principles (see also Chapter 55).[4]

In this chapter, we review the benefits of full-time intensivists and the impact of "closed ICUs" (defined below) on patient outcomes. Much of this literature makes no distinction between improved outcomes in general and decreased harm in particular. However, given the high mortality[5] and complication rates[6-8] observed in ICUs, it seems reasonable to consider global interventions such as organizational changes as patient safety practices.

Practice Description

The following practice definitions are synthesized from studies reviewed for this chapter. For all of these models, the term "intensivist" refers to a physician with primary training in medicine, surgery, anesthesiology or pediatrics followed by 2-3 years of critical care medicine (CCM) training.

Open ICU model—An ICU in which patients are admitted under the care of an internist, family physician, surgeon or other primary attending of record, with intensivists available providing expertise via elective consultation. Intensivists may play a *de facto* primary role in the management of some patients, but only within the discretion of the attending-of-record.

Intensivist Co-management—An open ICU model in which all patients receive mandatory consultation from an intensivist. The internist, family physician, or surgeon remains a co-attending-of-record with intensivists collaborating in the management of all ICU patients.

Closed ICU model—An ICU in which patients admitted to the ICU are transferred to the care of an intensivist assigned to the ICU on a full-time basis. Generally, patients are accepted to the ICU only after approval/evaluation by the intensivist. For periods typically ranging from one week to one month at a time, the intensivist's clinical duties predominantly consist of caring for patients in the ICU, with no concurrent outpatient responsibilities.

Mixed ICU models—In practice, the above models overlap to a considerable extent. Thus, some studies avoid attempting to characterize ICUs in terms of these models and focus instead on the level of involvement of intensivists in patient care regardless of the organizational model. This involvement may consist of daily ICU rounds by an intensivist (thus including "closed model ICUs" and "intensivist comanagement"), ICU directorship by an intensivist (possibly including examples of all 3 models above), or simply the presence of a full-time intensivist in the ICU (also including examples of all 3 models.)

Intensivist models—ICU management may include all of these models. These models are contrasted with the open ICU model, in which an intensivist generally does not participate in the direct care of a significant proportion of the ICU patients.

Prevalence and Severity of the Target Safety Problem

ICUs comprise approximately 10% of acute care hospital beds.[9] The number of annual ICU admissions in the United State is estimated to be 4.4 million patients.[10] Due to an aging population and the increasing acuity of illness of hospitalized patients, both the total number of ICU patients and their proportional share of hospital admissions overall are expected to grow.[11]

ICU patients have, on average, mortality rates between 12 and 17%.[25] Overall, approximately 500,000 ICU patients die annually in the United States. A recent review estimated that this mortality could be reduced by 15 to 60% using an intensivist model of ICU management.[12]

Young and Birkmeyer have provided estimates of the relative reduction in annual ICU mortalities resulting from conversion of all urban ICUs to an intensivist model of management model.[10] Using conservative estimates for current ICU mortality rates of 12%, and estimating that 85% of urban ICUs are not currently intensivist-managed, the authors calculated that approximately 360,000 patients die annually in urban ICUs without intensivists. A conservative projection of a 15% relative reduction in mortality resulting from intensivist-managed ICUs yields a predicted annual saving of nearly 54,000 lives.

By only measuring ICU mortality rates, this analysis may underestimate the importance of intensivist-managed ICUs. In addition to mortality, other quality of care outcome measures that might be improved by intensivists include rates of ICU complications, inappropriate ICU utilization, patient suffering, appropriate end-of-life palliative care, and futile care.

Opportunities for Impact

Currently, a minority of ICUs in the United States utilizes the intensivist model of ICU management.[13] Intensivists are even less frequently found in non-teaching and rural hospitals. The potential impact of the intensivist model is far-reaching.

Study Designs

Among 14 studies abstracted for this chapter, 2 were systematic reviews and 12 were original studies. One systematic review is an abstract that has not yet appeared in journal form and does not provide cited references.[12] The other systematic review evaluated 8 references, all of which are included in this chapter.[10] An additional 4 studies absent from the systematic review are included here. These 4 studies include 2 abstracts that were published after the 1999 systematic review,[14,15] and 2 studies of pediatric ICUs with intensivists.[16,17]

Among the original studies, 6 incorporated historical controls and 5 used a cross-sectional approach. One study[18] had both historical and cross-sectional components. The original studies include 4 studies of adult medical ICUs, 6 studies of adult surgical ICUs and 2 studies of pediatric multidisciplinary ICUs. Intensivist models used by the studies cited for this review include 4 closed ICUs, 4 mixed ICUs, 3 ICUs with intensivist comanagement and one open ICU.

Several studies were excluded, including abstracts with insufficient data,[19-25] unclear distinctions in patient management between control groups and intervention (intensivist managed) groups,[26,27] intensivist models that may have important roles in future practice (eg, telemedicine consultation with remote management) but are not yet widely available[28,29] and considerably older studies.[30]

Study Outcomes

Required outcomes of interest in studies chosen for this chapter were ICU mortality, overall in-hospital mortality, or both. Some studies also included morbidity outcomes, adverse events and resource utilization (eg, length of ICU and hospital stay), levels of patient acuity or severity of illness (ICU utilization) and levels of high-intensity intervention usage. Studies addressing the impact of intensivist ICU management on resource utilization without mortality or outcome data were excluded. There are no data regarding the impact of intensivists.

Evidence for Effectiveness of the Practice

As shown in Table 38.1, most of the studies report a decrease in unadjusted in-hospital mortality and/or ICU mortality, although this decrease did not reach statistical significance in 3 of the 14 studies.[16,18,31] One study found a statistically insignificant increase in the unadjusted mortality rates associated with the intensivist model ICU.[32] This study also found that the ratio of expected-to-actual mortality was reduced in the intensivist-model ICUs. This finding was associated with a higher severity of illness scores in the intensivist-model ICU population. A similar finding of significantly improved outcomes after adjusting for severity of illness and comparing expected-to-actual mortality rates was demonstrated in one pediatric study.[16] Overall, the relative risk reduction for ICU mortality ranges from 29% to 58%. The relative risk reduction for overall hospital mortality is 23% to 50%. These results are consistent with those of a previous systematic review that found a 15% to 65% reduction in mortality rates in intensivist-managed ICUs.[10]

Data concerning long-term survival (6 and 12 months) for patients cared for in ICUs with and without intensivist management is not available. Differences in outcomes between closed ICUs, mixed ICU models and co-managed ICUs are difficult to assess. Studies that have addressed conversion from an open to a closed model did not utilize full-time intensivists in the open model study phases.[18,32-34] Therefore it is not clear to what extent improved patient outcomes resulted only from changes in intensivists' direct patient care and supervision.

The observational studies evaluating these practices suffer from 2 major limitations. Half of the studies retrospectively compared post-implementation outcomes with those during an historical control period. Because none of these studies included a similar comparison for a control unit that remained open in both time periods, we lack information on secular trends in ICU outcomes during the time periods evaluated. The other major limitation associated with comparing mortality rates for ICU patients relates to differences in ICU admission and discharge criteria under different organizational models. Under the intensivist model, patients are generally accepted to the ICU only after approval/evaluation by the intensivist. Thus, conversion to an intensivist model ICU may bring about changes in the ICU patient population that are incompletely captured by risk-adjustment models and confound comparisons of mortality rates. Moreover, these changes in ICU admitting practice may exert contradictory effects. For example, an intensivist model ICU may result in fewer ICU admissions for patients with dismal prognoses, and less futile care for patients already in the ICU. On the other hand, intensivist-managed ICUs with stricter admission and discharge criteria may result in a greater overall acuity of illness for the ICU patients and therefore higher mortality rates.

Potential for Harm

The potential for harm resulting from intensivist management is unclear. Concerns raised in the literature about intensivist-managed ICUs include the loss of continuity of care by primary care physicians, insufficient patient-specific knowledge by the intensivist,[35] reduced use of necessary sub-specialist consultations, and inadequate CCM training of residents who formerly managed their own ICU patients.

Perhaps more worrisome is the impact that adoption of this practice would have on physician staffing and workforce requirements. Without a substantial increase in the numbers of physicians trained in CCM, projected increases in the ICU patient population over the next 30 years will result in a significant shortfall in the intensivist workforce.[11]

Costs and Implementation

These studies did not address the incremental costs associated with implementation of full-time intensivists. Several studies have analyzed resource utilization and length of stay associated with intensivist-managed ICUs.[13,16,18,19,29,31,32,36] The results of these studies are variable with respect to costs. Some demonstrate a decrease in ICU expenses. Others found increased costs, likely due to the increased use of expensive technologies. Still others show little overall cost differential. The cost-effectiveness and cost-benefit of an intensivist-model ICU requires further study.

Comment

Outcomes research in critical care is particularly challenging for several reasons. It typically relies on observational outcomes studies, and must account for the diversity and complexity of variables measured and controlled for, such as patient-based, disease-based, provider-based and therapy-based variables. Despite these challenges and limitations, the literature fairly clearly shows that intensivists favorably impact ICU patient outcomes. What remains unclear is which intensivist model to recommend—intensivist consultation versus intensivist co-management versus closed ICUs. Also, we do not know the degree to which the choice among these models depends on intensivist background – ie, medicine, anesthesiology or surgery. Finally, because the mechanism of the benefit of intensivist models is unknown, the degree to which this benefit can be captured by other changes in practice (eg, adoption of certain evidence-based processes of ICU care) remains unclear.

The major incentive for clarifying these issues concerns the implications for staffing ICUs in the future. While the evidence supports the beneficial role of full-time intensivists, the current number of trainees is insufficient to keep pace with the expected increase in the number of ICU patients.[11] Until we are able to sufficiently increase the size and number of CCM training programs for physician specialists, complementary solutions for meeting critical care management demands should be considered. These might include incorporating physician-extenders such as nurse practitioners and physician assistants with specialized critical care training, increased participation by hospitalists in care of ICU patients,[37] regionalization of critical care services,[38] or providing innovative methods to extend intensivists' expertise to remote sites through telemedicine consultations.[28] The latter practice seems particularly promising—a recent time series cohort study found an approximately 33% decrease in severity-adjusted hospital mortality and a nearly 50% decrease in ICU complications when a technology-enabled remote ICU management program was instituted in a community-based ICU.[28]

Table 38.1. Intensivist management in the care of critically ill patients*

Study Setting	Study Year	ICU Type	Study Design, Outcomes	Intensivist Intervention	Mortality Relative Risk Reduction (%)	
					ICU	Hospital
Closed ICU Model						
Tertiary care, urban, teaching hospital; patients with septic shock; historical control[33]	1982-1984	MICU	Level 3, Level 1	Closed	NA	23
Teaching hospitals (n=2); two study designs using historical and concurrent controls[18]	1992-1993	MICU	Level 3, Level 1	Closed	NA	Retrospective: 19 (p=NS) Prospective: 26 (p=NS)
Tertiary care, urban, teaching hospital; historical control[32]	1993-1994	MICU	Level 3, Level 1	Closed	NA	-38 (p=NS)† 0/E 13‡
Tertiary care, urban, teaching hospital; historical control[34]	1995-1996	SICU	Level 3, Level 1	Closed	58	50§
Mixed ICU models						
ICUs (n=16) with different characteristics; cross-sectional[16]	1989-1992	Pediatric MICU SICU	Level 3, Level 1	Mixed	RRR 25¶ OR 1.5**	NA
ICUs (n=39) with different characteristics; cross-sectional. Patients with abdominal aortic surgery[38]	1994-1996	SICU	Level 3, Level 1	Mixed	NA	OR 3.0§§
ICUs (n=31) with different characteristics; cross-sectional. Patients with esophageal resection[14]	1994-1998	SICU	Level 3, Level 1	Mixed	NA	RRR 73¶ OR 3.5**
ICUs (n=39) with different characteristics; cross-sectional. Patients with hepatic resection[15]	1994-1998	SICU	Level 3, Level 1	Mixed	NA	RRR 81¶ OR 3.8**
Community teaching hospital; historical control[40]	1992-1994	MICU	Level 3, Level 1	Open	29	28
Co-managed ICUs						
Tertiary care ICU in a teaching children's hospital[16]	1983-1984	Pediatric MICU SICU	Level 3, Level 3	Co-manage	48 (p=NS)	NA
Tertiary care, Canadian teaching hospital; historical control[39]	1984-1986	SICU	Level 3, Level 1	Co-manage	52	31
Tertiary care, urban, teaching hospital; cross-sectional comparison (concurrent control)[31]	1994-1995	SICU	Level 3, Level 1	Co-manage	NA	32 (p=NS)

* ICU indicates intensive care unit; MICU, medicalintensive care unit; Mixed, mixed intensivist model (including daily ICU rounds by an intensivist, the presence of a full-time intensivist, open units with comanagement and closed units with mandatory consultations or only intensivist management); NA, not available as outcome (was not evaluated); NS, not stastically significant; and SICU, surgical intensive care unit.

† Negative value indicates an increase in relative risk of mortality.

‡ O/E is observed to expected mortality ratio based risk adjustment

§ Hospital mortality measured 30-days after discharge

¶ RRR is the unadjusted mortality relative risk reduction
** OR is the adjusted odds ratio of increased mortality associated without an intensivist model.

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REF 2: CARSON ET AL

Effects of Organizational Change in the Medical Intensive Care Unit of a Teaching Hospital

A Comparison of 'Open' and 'Closed' Formats

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Objective.—To compare the effects of change from an open to a closed intensive care unit (ICU) format on clinical outcomes, resource utilization, teaching, and perceptions regarding quality of care.

Design.—Prospective cohort study; prospective economic evaluation.

Setting.—Medical ICU at a university-based tertiary care center. For the open ICU, primary admitting physicians direct care of patients with input from critical care specialists via consultation. For the closed ICU, critical care specialists direct patient care.

Patients.—Consecutive samples of 124 patients admitted under an open ICU format and 121 patients admitted after changing to a closed ICU format. Readmissions were excluded.

Main Outcome Measures.—Comparison of hospital mortality with mortality predicted by the Acute Physiology and Chronic Health Evaluation II (APACHE II) system; duration of mechanical ventilation; length of stay; patient charges for radiology, laboratory, and pharmacy departments; vascular catheter use; number of interruptions of formal teaching rounds; and perceptions of patients, families, physicians, and nurses regarding quality of care and ICU function.

Results.—Mean±SD APACHE II scores were 15.4±8.3 in the open ICU and 20.6±8.6 in the closed ICU (P=.001). In the closed ICU, the ratio of actual mortality (31.4%) to predicted mortality (40.1%) was 0.78. In the open ICU, the ratio of actual mortality (22.6%) to predicted mortality (25.2%) was 0.90. Mean length of stay for survivors in the open ICU was 3.9 days, and mean length of stay for survivors in the closed ICU was 3.7 days (P=.79). There were no significant differences between periods in patient charges for radiology, laboratory, or pharmacy resources. Nurses were more likely to say that they were very confident in the clinical judgment of the physician primarily responsible for patient care in the closed ICU compared with the open ICU (41% vs 7%; P<.01), and nurses were the group most supportive of changing to a closed ICU format before and after the study.

Conclusions.—Based on comparison of actual to predicted mortality, changing from an open to a closed ICU format improved clinical outcome. Although patients in the closed ICU had greater severity of illness, resource utilization did not increase.

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INTENSIVE CARE UNITS (ICUs) were created to provide specialized nursing care and monitoring in a consolidated area. Over time, physicians with critical care expertise have become increasingly available. The organization of medical staff in the ICU should facilitate exemplary patient care in the most effective and cost-efficient manner possible.

Most institutions have implemented care by critical care staff with either an "open" or "closed" ICU model.[1-4] In the open system, patients are admitted to the ICU under the care of a primary care physician. In many open ICUs, critical care specialists are available to provide expertise via consultation. In the closed system, patients requiring ICU admission are transferred to the care of the critical care specialist or team. The relative merits of these 2 models of ICU practice are often debated, usually in the absence of data to inform discussion.

Our 600-bed university teaching hospital, situated in an urban community, provides all levels of care to patients from a variety of socioeconomic backgrounds. There is a medical school as well as residency and fellowship training programs in most specialties and medical subspecialties, including pulmonary and critical care. Our 10-bed medical ICU had been organized in an open format, which allowed all medical services to admit patients and write orders in the ICU. The admitting attending physician and house staff under his or her supervision retained primary responsibility for the patient's care. A critical care team examined every patient on a daily basis as a mandatory consult service and made recommendations for management. On February 1, 1994, our ICU changed to a closed format where the critical care team assumed primary responsibility for all patients admitted to the ICU. We sought to use this opportunity to compare the merits of these organizational strategies.

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METHODS

Setting

Open Format.—Patients were admitted to the medical ICU by attending physicians or residents from any of our medical services including general medicine, hematology/oncology, gastroenterology, and neurology. Patients with primary cardiac problems were admitted to a separate coronary care unit and were not included in either portion of this study. Primary responsibility for patient management resided with the admitting attending physician and house staff on that service. An ICU team consisting of a board-certified critical care specialist, a fellow in pulmonary and critical care medicine, a medical resident (postgraduate year [PGY] 2 or 3), 3 medical interns (PGY 1), and 2 to 4 medical students functioned as a mandatory consulting service on all patients admitted to the medical ICU from any service. Daily recommendations for management were made by the ICU team on all patients, but no orders could be written without permission from the primary admitting service. The interns on the ICU team assisted with overnight coverage of the ICU patients on the general medicine, hematology/oncology, and gastroenterology services and had order-writing privileges during those hours only for acute cross-coverage issues. A team of nephrologists rounded on all patients requiring dialysis, and they wrote orders related to dialysis only.

Closed Format.—An ICU team directed by a critical care specialist assumed full responsibility for patients that would have previously been admitted to the ICU by the general medicine, hematology/oncology, gastroenterology, or neurology services. The ICU team now consisted of a board-certified critical care specialist, a fellow training in pulmonary and critical care medicine, 3 medical residents (PGY 2 or 3), 3 medical interns (PGY 1), and 2 to 4 medical students. Order-writing privileges belonged exclusively to the house staff on the ICU team. Members of the original ward service were encouraged to round on their patients after transfer to the closed ICU, but they did not have order-writing privileges. Nephrologists continued to write orders relating to dialysis only.

Critical care specialist staff did not change between study periods. Most of the house staff who were on the ICU team during the closed ICU study period also had admitting privileges during the open ICU study period. Nursing and ancillary personnel remained unchanged as well, as did policies and protocols.

On discharge from the open ICU, the patients would continue to be managed by the physicians who took care of them in the ICU. On discharge from the closed ICU, patients would be transferred to a medical ward service. If a patient had been on a medical ward service prior to admission to the closed ICU, they would be transferred back to the original ward service.

If it was determined that a patient had no chance of recovery from their acute illness and that they should be treated for comfort only, the patients were transferred from the ICU to the medical ward unless it was apparent that their demise was imminent or the intensity of nursing care was too high. The decision to withdraw aggressive care was made by the attending physician on the primary admitting service in the open ICU period and by the attending physician on the ICU team during the closed ICU period.

Study Periods

The study period for the open format was from October 1 through November 30, 1993. The study period for the closed format was from April 1 through May 31, 1994. A 2-month adjustment period was allowed after the initial change in format on February 1, 1994, before data were collected.

Patient Eligibility and Enrollment

There were 124 patients enrolled in the open ICU study period and 121 patients enrolled in the closed ICU study period. All patients admitted to the medical ICU during the study period were eligible for enrollment. If patients had to go to a different ICU because of overload or space problems, they were still followed by the ICU consult team in the open ICU study period, and they were still managed by the ICU team during the closed ICU period. Therefore, these patients were included in the study. Only a patient's first admission during each study period was included to avoid counting 2 outcomes for the same individual. Any patient already admitted to the ICU before the start of either study period was excluded. Data were collected on all patients enrolled during the study periods until the end of their hospital admission.

Measurement of Clinical Outcomes

The Acute Physiology and Chronic Health Evaluation II (APACHE II) system[5] was used to measure severity of illness and predicted death rates for the 2 groups of patients. APACHE II scores for all eligible patients were determined from clinical information obtained during the first 24 hours of admission to the ICU. A total of 42 patients during the first study period and 27 patients during the second study period did not have arterial blood gas measurements during the first 24 hours of their admissions because they had no perceived respiratory or acid-base problems. Therefore, these values were assumed to be normal, and no points were given. All other values were available for all patients in the study except for 1 patient who did not have serum creatinine levels measured. This, too, was assumed to be normal. Chronic health status based on definitions provided in the APACHE II literature[5] was assigned by 2 reviewers after review of each patient's medical record. Diagnostic category weights were assigned to all patients by a single reviewer, using the same criteria for both study periods. Predicted deaths were computed as the sum of individual risks with a multiple logistic regression equation as published by Knaus et al.[5]

Patients were followed during their hospital admission and mortality was determined. Data also were collected for duration of mechanical ventilation until the first extubation, number of patients requiring reintubation (unsuccessful extubations), and number of patients who were ventilator dependent at the time of ICU discharge. The number of patients receiving face mask ventilation were also recorded. Mechanical ventilation data were collected by patient observation or daily examination of patient records. Data indicating which patients received cardiopulmonary resuscitation (CPR) during their hospital admission were obtained from the Cardiopulmonary Resuscitation Subcommittee of the University of Chicago (Ill) Medical Staff, which collects this information daily.

Measurement of Resource Utilization

For each patient in each study period, overall charge data for the laboratory, pharmacy, and radiology departments and total hospital charges were obtained. Charges during the ICU admission as well as pre- and post-ICU admission were examined both separately and in combination. In addition, charges and number of tests ordered were obtained for a group of "indicator tests." The following indicator tests were chosen by the investigators as those whose use was thought most likely to be affected by the change in the organization of the ICU: chest x-ray films, arterial blood gases, complete blood cell counts, and standardized blood electrolyte panels. Length of stay, charges, and test utilization were obtained from the University of Chicago Hospitals' Office of Program Evaluation using the management database of the Burroughs Health Information System.

Changes in hospital charges for tests, laboratory evaluations, and procedures go into effect with the new fiscal year, beginning July 1. Since the study period did not span a change in fiscal year, no significant change in charges occurred between study periods.

A group of indicator drugs was also selected for study on the basis of expected impact from organizational change in the ICU. These included antibiotics, stress ulcer prophylactics, neuromuscular blockers, analgesics, and sedative/hypnotics. Data for number of drugs used and hospital drug cost per patient were obtained by review of pharmacy dispensary records. In determining the number of drugs used in each class, no distinction was made for route of administration.

Data for vascular catheter use, including total number and average duration of use of arterial lines, central venous lines, and pulmonary artery catheters, were collected. Vascular catheter data were obtained from daily examination of patient records, including physicians' and nurses' notes, procedure notes, and nursing care flow charts.

The length of time required to effect patient transfer out of the ICU was recorded for both study periods as an indicator of cooperation and communication between physicians, ICU nurses, and floor nurses.

Interruptions of Formal Teaching Rounds

Under the original open ICU format, an important function of the ICU attending physician was to present a defined syllabus of principles of critical care medicine for house staff and students on the ICU consult team during daily didactic teaching rounds. Formal ward teaching rounds were a part of the daily routine on the medical wards for all primary medical services as well. Interruption of teaching rounds on the wards for patient management issues in the ICU was frequently identified by faculty as an obstacle to teaching.

To objectively assess the effects of organizational change on interruption of formal teaching rounds in the ICU and on the general medicine service, we quantified the number and type of interruptions during teaching rounds for both study periods. One of 3 trained observers attended a sample 10 teaching rounds in the ICU and 10 teaching rounds on 4 different general medicine services. The number and length of interruptions were recorded.

Patient, Family, Physician, and Nurse Perceptions

Eligible patients and 1 family member per patient were interviewed in a standardized manner regarding their perceptions of the following issues related to the care in the ICU: satisfaction with decision making, information access, availability of emotional support, physician-patient relationships, nurse-patient relationships, and perceived level of care. During each study period, patients whose ICU admissions lasted greater than 24 hours were considered eligible for interview. All eligible patients who consented were interviewed unless they were noncommunicative, heavily sedated, or near death. Interviews during both study periods were performed by the same 2 investigators.

Professional staff (including attending physicians from the medical services and the ICU), house staff, and nurses who were employed full-time in the medical ICU completed questionnaires addressing the following issues regarding their perceptions of the change in ICU organization: time commitment and time management, independent and collaborative decision making, education, satisfaction, and factors directly affecting patient care.

Most of the questions in the surveys and questionaires were adapted from those used since 1991 by the 60 members of the University Hospital Consortium, which had been adapted from the well-validated instrument of the Picker Commonwealth Foundation.[6] Questions were presented in Likert-type formats. For questions developed specifically for this project, face validity was assessed by small groups in each respondent category before the research began, and pretests of each instrument were conducted.

Statistical Methods

Data were analyzed using SAS PC (SAS Institute Inc, Cary, NC). Means±SDs are reported, t tests were used to assess differences between means of 2 groups, χ^2 tests were used to test for associations between categorical variables, and logistic regression was used to assess multivariate relationships.

The project was reviewed and approved by the institutional review board.

Table 1.—Mortality and Predicted Mortality*

	ICU Format			
	Open	Closed	95% CI Difference	P
No. of admissions	124	121	...	...
APACHE II score, mean±SD	15.4±8.3	20.6±8.6	−10.4 to −3.1	.001
Hospital mortality, %	22.6	31.4	−19.9 to 2.2	.12
Predicted mortality, %	25.2	40.1	...	...
Ratio of hospital mortality to predicted mortality	0.90	0.78	...	...

*ICU indicates intensive care unit; CI, confidence interval; and APACHE II, Acute Physiology and Chronic Health Evaluation II.

RESULTS

Clinical Outcomes

The patients in the closed ICU had a higher mean±SD age than patients in the open ICU (59±18 years vs 53±19 years; $P<.05$). Sepsis, hemorrhagic shock/hypovolemia, and gastrointestinal bleeding were the most common primary diagnoses during both study periods. There were 13 postoperative patients (10%) in the open ICU and 6 postoperative patients (5%) in the closed ICU. Patients in the closed ICU had higher mean APACHE II scores (20.6±8.6 vs 15.4±8.3; $P=.001$). There was no significant difference between the closed ICU and open ICU in hospital mortality (Table 1).

In the closed unit, the ratio of actual mortality (31.4%) to predicted mortality (40.1%) was 0.78. In the open ICU, the ratio of actual mortality (22.6%) to predicted mortality (25.2%) was 0.90 (Table 1).

Patients who received mechanical ventilation in the closed ICU had significantly ($P=.001$) higher APACHE II scores than mechanically ventilated patients in the open ICU (Table 2), but there were no significant differences between the closed and open ICU in mortality or in duration of mechanical ventilation for survivors. The number of patients either requiring reintubation or unable to be extubated during their ICU admission were similar in both groups. More patients received face mask ventilation in the closed ICU, but the difference was not statistically significant ($P=.18$).

Of the 28 patients who died during their hospital admission in the open ICU period, 25 (89%) did not receive CPR at the time of death. Of the 38 patients who died during the closed ICU period, 33 (87%) did not receive CPR at the time of death. Of the patients who died without receiving CPR, 11 (44%) in the open ICU were receiving mechanical ventilation at the time of death compared with 18 (54%) in the closed ICU. These differences were not statistically significant ($P=.91$).

Resource Utilization

Average ICU length of stay for survivors in the open ICU was 3.9 days, and

Table 2.—Characteristics of Patients Receiving Mechanical Ventilation (MV)*

Characteristic	ICU Format: Open	ICU Format: Closed	P
Patients requiring MV, No. (% admissions)	49 (40)	63 (52)	.06
APACHE II scores for MV patients, mean±SD	20.51 (±8.24)	24.63 (±7.83)	<.001
Mortality for MV patients, %	34.0	46.8	.33
Duration of MV after initial intubation for ICU survivors, h, mean±SD	126.93 (±188.39)	115.96 (±105.5)	.75
No. requiring reintubation	6	3	NC
No. ventilator dependent at ICU discharge	5	4	NC
Face mask ventilation	9	15	.18

*ICU indicates intensive care unit; APACHE II, Acute Physiology and Chronic Health Evaluation II; and NC, not calculated.

Table 3.—Length of Stay*

	ICU Format: Open	ICU Format: Closed	95% CI Difference	P
In unit				
Survivors	3.9±7.0	3.7±3.9	−1.2 to 1.6	.79
All patients	4.4±7.1	4.9±6.3	−2.2 to 1.2	.57
In hospital				
Survivors	14.8±14.8	16.2±15.1	−3.5 to 5.0	.52
All patients	16.7±19.4	15.9±14.2	−5.2 to 2.4	.75

*Data are expressed as mean±SD number of days. ICU indicates intensive care unit; and CI, confidence interval.

Table 4.—Mean Charges per Patient*

	ICU Format: Open	ICU Format: Closed	95% CI Difference	P
Laboratory	1906	1800	−367 to 578	.66
Arterial blood gas	430	467	−117 to 43	.41
Complete blood cell count	69	67	−8 to 12	.66
Kidney profile	126	117	−10 to 28	.38
Radiology	374	431	−195 to 79	.40
Chest x-ray film	262	274	−51 to 27	.58
Pharmacy	1374	1254	−483 to 723	.69

*Data expressed as $/d in intensive care unit (ICU). CI indicates confidence interval.

average length of stay for survivors in the closed ICU was 3.7 days (Table 3). Average ICU length of stay for all patients was 4.37 days in the open ICU and 4.86 days in the closed ICU. Average length of stay in the hospital for survivors including ICU days was 14.8 days in the open ICU and 16.2 days in the closed ICU. Hospital length of stay for all patients was 15.9 days in the closed ICU and 16.7 days in the open ICU. None of these differences were statistically significant.

When comparing mean charges per patient per unit day for laboratory, radiology, and pharmacy resources, there were no differences noted between the closed and open ICU periods (Table 4). There were also no differences between charges for the laboratory and radiology indicator tests. No statistically significant differences were noted when charges were stratified by APACHE II score or hospital survival (data not shown). There were significant increases, however, in the use of neuromuscular blockers and sedative/hypnotic drugs in the closed ICU (Table 5) as determined by the number of drugs used in each category (as well as actual drug cost per patient for sedative/hypnotic drugs). Use of antibiotics, stress ulcer prophylactics, and analgesics were similar in the open and closed ICU study periods.

In regard to vascular catheter use, more patients received arterial lines, central venous lines, and pulmonary artery catheters in the closed ICU (Table 6), and they were used for a longer average duration.

Occupancy rate in the medical ICU was 76% for the open ICU study period and 95% for the closed ICU study period. Nurse/patient ratios were maintained at 1:1 or 1:2 at all times. Staffing was adjusted each shift based on occupancy. The average time required for transfer of patients out of the ICU after notification of the floor nurse decreased from 280 minutes in the open ICU to 241 minutes in the closed ICU. In addition, there were 30 instances of transfers being canceled after notification of the floor nurse in the open ICU compared with only 4 instances in the closed ICU.

Interruption of Formal Teaching Rounds

Formal ICU teaching rounds were interrupted for ICU patient issues much more frequently and for longer periods of time in the closed ICU (124 interruptions; mean duration, 21.2 minutes) compared with the open ICU (28 interruptions; mean duration, 7.0 minutes). Total minutes of formal teaching rounds observed in the closed ICU (659 minutes) were significantly less than in the open ICU (1231 minutes) because patient care responsibilities necessitated discontinuation of many didactic sessions. General medicine teaching rounds were not significantly affected by the change in ICU organization.

Patient and Family Perceptions

There were 92 eligible patients in the first study period, of which 52 patients and 48 families were interviewed. Of the 52 patients interviewed in the first study period, 30 had families available for interview. There were 94 eligible patients in the second study period, of which 50 patients and 49 families were interviewed. Of the 50 patients interviewed in the second study period, 31 had families available for interview. The number of persons who responded to each question varied slightly, and missing values are excluded from proportions reported. Seventy-five percent of patients interviewed in the first study period and 82% of patients interviewed in the second study period had APACHE II scores greater than 10.

Decision Making.—Although most patients and families (>67%) indicated that they agreed with decisions made about the patient while in the ICU, more than 20% of patients and families in both formats indicated that they wished to be more involved in decision making regarding their care. In both study periods, 30% of patients stated that they were not at all involved in decisions made about their care. There were not significant differences between the study periods.

Information Access.—More families in the closed than the open format said that it was very easy to find a doctor to talk with (66% vs 41%; $P<.05$). In both formats, however, greater than 60% of the families interviewed stated that the nurse was the individual most likely to answer questions and address concerns about the patient's medical situation.

Availability of Emotional Support.—More patients in the closed format reported that it was hard or very hard to find someone on the unit staff to provide emotional support (39% vs 20%; $P<.05$) and often "too little emotional support" was offered in the closed unit (39% vs

Table 5.—Indicator Drugs*

Indicator Drugs	ICU Format		95% CI Difference	P
	Open	Closed		
Mean No. per patient per ICU admission				
Antibiotics	2.53	2.61	−0.60 to 0.76	.81
Stress ulcer prophylactics	1.03	1.17	−0.04 to 0.32	.11
Neuromuscular blockers	0.10	0.22	0.06 to 0.23	.03
Analgesics	0.73	0.94	−0.01 to 0.43	.06
Sedative/hypnotics	0.80	1.19	0.10 to 0.69	.008
Total	5.20	6.14	−0.18 to 2.06	.09
Cost per patient, $/d				
Antibiotics	250.77	232.76	−111.04 to 147.05	.78
Stress ulcer prophylactics	29.42	32.23	−8.98 to 14.59	.63
Neuromuscular blockers	25.76	76.69	−62.82 to 164.67	.37
Analgesics	3.82	5.25	−1.31 to 4.16	.30
Sedative/hypnotics	123.98	255.82	10.99 to 252.69	.03
Totals	433.75	602.75	−124.28 to 462.26	.25

*ICU indicates intensive care unit; and CI, confidence interval.

Table 6.—Vascular Catheter Use for Open and Closed Intensive Care Unit (ICU) Formats

	ICU Format		P
	Open	Closed	
No. of patients receiving lines			
Arterial line	65	78	.07
Central venous line	37	56	.02
Pulmonary artery catheter	23	41	.002
All lines	74	90	.02
Average duration per line, h			
Arterial line	70	80	.23
Central venous line	78	99	.07
Pulmonary artery catheter	67	74	.92
All lines	73	86	.04

12%; $P<.05$). In both formats, patients and families perceived nurses to provide the bulk of emotional support.

Perceived Level of Care.—In the open ICU, 44.2% of patients and 45.8% of families evaluated patient care as excellent compared with 52.1% ($P=.06$) and 59.2% ($P=.26$) in the closed ICU.

Physician and Nurse Perceptions

Response rate to questionaires in the open ICU study period were as follows: nurses, 94%; house staff, 83%; and attendings, 100% (including 16 ward attendings and 2 critical care physicians). In the closed ICU study period, the response rates were as follows: nurses, 85%; house staff, 78%; and attendings, 73% (including 13 ward attendings and 3 critical care physicians). The number of persons who responded to each question varied slightly, and missing values are excluded from proportions reported.

Continuity of care was rated as poor by none of the house staff or attending physicians in the open ICU compared with 23.8% ($P<.001$) and 33.3% ($P<.05$), respectively, in the closed ICU. House staff responded that the ICU service was very important in making patient care decisions in the closed system compared with the open system (95% vs 39%; $P<.01$). With regard to independence in making patient care decisions, 5% of house staff in the open ICU felt that they needed more independence compared with 41% in the closed ICU ($P<.05$). Opportunities to learn were rated as poor by 2% of the house staff in the open ICU compared with 23% in the closed ICU ($P<.05$), and opportunities to teach were rated as poor by 5% of house staff in the open ICU compared with 32% in the closed ICU ($P<.05$). However, 43% of house staff reported being very comfortable in managing ICU patients after rotations in the closed system compared with 24% in the open system ($P<.05$). Also, 52% of house staff in the closed system rated their level of experience in managing ICU patients as "very experienced" compared with 15% in the open ICU ($P<.05$).

There were few statistically significant differences between responses to questionnaires by nurses. However, nurses were more likely to say that they were very confident in the clinical judgment of the physician primarily responsible for patient care in the closed system compared with the open system (41% vs 7%; $P<.01$).

When asked directly if they support the change to a closed format, 55% of attending physicians responded as being supportive or very supportive before the change compared with 33% ($P=.71$) after the change. Sixty-nine percent of house staff and 93% of nurses were supportive or very supportive before the change compared with 70% ($P=.71$) and 86% ($P=.23$), respectively, after the change.

COMMENT

A nationwide survey in 1991[1] of American Hospital Association–registered hospitals revealed that 22% of the responding hospitals' ICUs used a closed format in which only ICU staff could write orders on ICU patients. Fifteen percent of the respondents indicated that patients were transferred to the service of the medical director of the unit on admission to the ICU. Larger hospital size, more specialized units, and medical school affiliation had the greatest influence on creation of closed ICUs. The relative merits of open or closed ICUs have been vigorously debated,[3] but data on the subject have not been available.

Several studies of individual ICUs demonstrated decreased ICU mortality when specialists trained in critical care were added to ICU physician staff either as consultants[7] or primary physicians[8-10] when specialist input previously had not been available. Three of the studies[8-10] documented an increase in utilization of monitoring devices such as pulmonary artery catheters and arterial catheters after involvement of critical care specialists.

An extensive study by Knaus et al[11] examined 13 hospitals with 3 different ICU organization and staffing patterns: level I units had full-time directors, high nurse-to-patient ratios, and a strong commitment to research; level II units had part-time directors and qualified designates in the hospital at all times, and high to intermediate nurse-to-patient ratios; and level III units had part-time directors who relied on other in-house physicians for coverage and had low nurse-to-patient ratios. They prospectively compared ratios of actual mortality to predicted mortality based on APACHE II scores in 5030 ICU patients. There were no significant differences in mortality ratios between level I and level II or level III ICU organization types. One of the hospitals had a significantly better mortality ratio than the other hospitals as a group. That hospital's ICU was staffed by senior-level in-house physicians and had high levels of physician-staff interaction and communication. Clinical protocols were prominently used, and that facility had the highest number of therapeutic interventions such as chest physical therapy and laboratory testing.

To our knowledge, there have been no reports in the literature evaluating the effect of a change in ICU organization from an open to a closed format on patient outcome or resource utilization without the confounding influences of institutional differences or additions of critical care specialists to physician staff. In our institution, on changing from an open to a closed ICU format, critical care specialists who had previously served as consultants assumed direct responsibility for patient management. We then prospectively studied the effects of these changes on important aspects of ICU function, including patient outcome, resource utilization, and teaching. In addition, we attempted to assess the effects of the organizational change on patient care and professional collaboration by collecting qualitative perception data from patients, their families, physicians, and nurses.

To compare clinical outcomes between groups of ICU patients with differing severity of illness, we used the APACHE II system to calculate predicted mortality for patients in both study periods. APACHE II uses 12 physiologic variables measured during the first 24 hours of admission as well as age and chronic health status to calculate APACHE II scores. These scores have been shown to correlate well with risk of subsequent hospital death.[5] By assigning each patient a principle diagnosis that led to ICU admission and factoring in whether patients are admitted after emergency surgery, the expected death rate can be calculated using a regression analysis equation provided by Knaus et al.[5] Validation of this system revealed an overall correct classification rate of 88.5% for individuals with a 0.50 predicted risk of death.[5]

Patients admitted to the closed ICU during our study were older and had a significantly greater level of illness severity. Comparison of actual and predicted mortality revealed that actual mortality was lower than predicted during the open and closed ICU study periods. However, this difference was greater in the closed ICU, indicating a better overall clinical outcome. Results for both study periods compare favorably with data obtained from other institutions.[11]

It is unclear why patients admitted during the closed ICU study period had greater severity of illness. The closed ICU team may have been more selective as to which patients needed intensive care. They also may have been influenced by a higher ICU occupancy rate during the second study period, which would have made it less likely that patients with borderline severity of illness would be admitted to the ICU. Another possibility is that primary physicians on the medical wards may have been reluctant to send patients with borderline severity of illness to the ICU because they did not wish to disrupt established physician-patient relationships. Finally, the differences in ICU disease severity between study periods may reflect random or seasonal differences in community disease patterns.

Patients receiving mechanical ventilation were selected as a subgroup for clinical outcome because such patients required the most input from the ICU team when they served as consultants in the open format. Although improved clinical performance in this area was expected in the closed ICU, mortality and other measures of clinical outcome for mechanically ventilated patients did not differ significantly between the open and closed ICU. However, it should be noted that mechanically ventilated patients in the closed ICU had greater severity of illness. Use of the APACHE II system to predict mortality for mechanically ventilated patients as a subgroup has not been validated. Hospital mortality for patients receiving mechanical ventilation under either format (34.0% open and 46.8% closed) compares favorably with overall mortality rates of 38% to 64% that are reported in the literature for mechanically ventilated nonoperative patients.[12-17] Duration of mechanical ventilation is an important measure to follow because of resource implications,[18] but wide variations between patients make conclusive data difficult to obtain unless adjusted for disease type.

The small number of patients who received CPR at the time of death (11% of the open ICU patients and 13% of the closed ICU patients) indicates an awareness by physicians in both ICU formats that patients having a grave prognosis would not benefit from CPR. Many of those patients still received rather aggressive care as evidenced by the fact that approximately half of them were receiving mechanical ventilation at the time of death. The type of ICU format was not a factor. Similar findings from another university-based medical center have been reported by Prendergast and Luce.[19] They found that CPR was initiated in 10% of deaths in their medical and surgical ICUs. Of the 90% of deaths that were preceded by a decision to limit life-saving medical treatment, 71% received life support measures but had them withdrawn, 6% had life support continued but died without attempts at resuscitation, and 14% had all life support measures withheld. They also noted that this was a significant change in practice from 5 years earlier when CPR was initiated in 49% of deaths in the same ICUs.

Intensive care unit and hospital lengths of stay were unchanged between the open and closed ICU formats despite the greater severity of illness in the closed ICU. There were no major changes in hospital admitting policies between study periods that could have affected ICU length of stay. The ICU length of stay in the second study period may have been affected by the higher occupancy rate by creating increased pressure to discharge patients to make beds available for new admissions.

Nurse-patient ratios were 1:1 or 1:2 at all times. Staffing was adjusted each shift based on occupancy. Although the occupancy rate was higher in the closed ICU period, total admissions and length of stay were similar for both study periods. This would indicate that much of the increased occupancy in the second study period is accounted for by patients from nonmedical ICUs that "overflowed" into the medical ICU. Those patients were not managed by the ICU service, and they were not included in the study. Therefore, physician-patient ratios remained nearly the same in both study periods, and care should not have been affected.

Despite the greater severity of illness of patients in the closed ICU, most measures of resource utilization in terms of laboratory, radiology, and pharmacy charges showed no differences between the closed or open ICU. The greater use of face mask ventilation, sedative/hypnotic drugs, neuromuscular blockers, and central lines in the closed ICU probably reflect differences in the severity of illness between the patient groups. This trend may also reflect differences in therapeutic approach by the intensivists and possibly a greater level of comfort with such measures by the house staff when under direct supervision of the intensivists. Increased use of central lines and neuromuscular blockers would be expected to improve patient outcome only if used for appropriate indications, but indications for their use were not evaluated in this study.

Although most of the house staff on the closed ICU team had admitting privileges to the open ICU for 2 months between the open and closed ICU study periods, they only would have managed an average of 6 patients each during this time. We feel that this limited amount of ICU patient contact for house staff between study periods had little impact on differences in patient outcome. House staff in the closed ICU managed significantly more critically ill patients over a month than they would have in the open ICU, and this most likely accounts for their perception that they felt more experienced in managing critically ill patients after their closed ICU rotation.

Frequent interruption of teaching sessions has been identified as an important obstacle to establishing an effective educational environment in a teaching hospital.[20-22] When the ICU team was changed from a consult service to a primary service with direct patient care responsibilities, there was less time overall for formal teaching rounds, and rounds were interrupted significantly more often for patient management issues. The house staff also indicated on questionnaires that they had less time to learn and teach in the closed ICU. However, house staff reported higher levels of comfort in managing critically ill patients after a closed ICU rotation compared with their experience in the open ICU. This perception could be attributed to closer contact with critical care specialists during work rounds and during decision-making processes in the closed ICU. It could also be attributed to the larger number of ICU patients that they were able to manage during their closed ICU rotation. The relative value of didactic teaching vs hands-on experience in learning how to manage critically ill patients should be the subject of more focused studies in the future. Also, our data do not indicate how comfortable house staff would be in managing patients in the ICU if they experience long breaks between closed ICU rotations. This would compare with the open ICU format where they manage a few patients in the ICU during every month that they are on a clinical rotation.

Attending physicians on the medical wards and house staff indicated that continuity of care for patients was significantly interrupted by admitting them to a closed ICU. Although those physicians had the opportunity to visit the patients on rounds while they were in the ICU, if they weren't directly responsible for the rapid pace of therapy and response they inevitably would be less informed and less involved in decisions. Detailed communication between physician teams when patients are transferred in or out of a closed ICU can help overcome this loss of continuity, but this requires significant effort from each physician.

Nurses reported a higher level of confidence with the clinical judgment of physicians primarily responsible for patient management in the closed ICU compared with the open ICU. This finding as well as the high level of support from the ICU nurses in favor of the closed ICU format is notable considering the relatively large amount of ICU care provided by nurses. The improvement in efficiency of transfer of patients out of the ICU may indicate an improvement in communication between physicians and nurses in the closed ICU.

Patient and family satisfaction improved slightly with the closed ICU format. Physicians were perceived to be more available to answer questions for patients and families in the closed ICU, but more patients in the closed ICU reported difficulty finding someone from the ICU staff to provide emotional support. Nurse-patient and physician-patient ratios did not change, so this might be attributed to the higher acuity of illness allowing less time for nurses and physicians to attend to patients' emotional needs. Interrupted continuity of care affecting physician-patient relationships may have been a factor also. Patients in both study periods identified nurses as the caregivers most likely to provide emotional support.

An unexpected finding during both study periods was that 30% of patients who were interviewed in the ICU stated that they were not at all involved in decisions made about their care. This suggests that physicians underestimate the ability of critically ill patients to participate in their own care. Awareness of this issue by physicians should result in more determined efforts to involve patients in decision making while they are being cared for in an ICU.

In summary, changing from an open to a closed ICU format improved clinical outcome for patients managed in an ICU that had already been functioning at a highly effective level. Despite the higher severity of illness of patients admitted to the closed ICU, the improvement in clinical outcome was achieved without an increase in resource utilization. Although formal teaching of house staff was interrupted more frequently in the closed ICU, house staff ultimately felt more comfortable and experienced in managing critically ill patients. Nurses were supportive of changing to a closed ICU format, in part because of higher confidence in the clinical judgment of the physician primarily responsible for patient care in the closed ICU. Overall patient and family satisfaction improved in the closed format, but patients from both formats identified a lack of involvement in decision making.

We believe these data support the use of a closed ICU organizational format in comparable clinical settings. We are reluctant to generalize this observation to environments that differ substantially in staffing, particularly nonteaching facilities. Further studies in these institutions are required. A longer study period with higher patient numbers may have provided more conclusive data regarding outcomes of mechanical ventilation, length of stay, and resource utilization. Finally, we have identified didactic teaching and preservation of patient-physician relationships as areas requiring special attention following change from an open to a closed ICU organizational format.

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REF 3: PRONOVOST ET AL

Physician Staffing Patterns and Clinical Outcomes in Critically Ill Patients

A Systematic Review

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Context Intensive care unit (ICU) physician staffing varies widely, and its association with patient outcomes remains unclear.

Objective To evaluate the association between ICU physician staffing and patient outcomes.

Data Sources We searched MEDLINE (January 1, 1965, through September 30, 2001) for the following medical subject heading (MeSH) terms: *intensive care units, ICU, health resources/utilization, hospitalization, medical staff, hospital organization and administration, personnel staffing and scheduling, length of stay*, and *LOS*. We also used the following text words: *staffing, intensivist, critical, care*, and *specialist*. To identify observational studies, we added the MeSH terms *case-control study* and *retrospective study*. Although we searched for non–English-language citations, we reviewed only English-language articles. We also searched EMBASE, HealthStar (Health Services, Technology, Administration, and Research), and HSRPROJ (Health Services Research Projects in Progress) via Internet Grateful Med and The Cochrane Library and hand searched abstract proceedings from intensive care national scientific meetings (January 1, 1994, through December 31, 2001).

Study Selection We selected randomized and observational controlled trials of critically ill adults or children. Studies examined ICU attending physician staffing strategies and the outcomes of hospital and ICU mortality and length of stay (LOS). Studies were selected and critiqued by 2 reviewers. We reviewed 2590 abstracts and identified 26 relevant observational studies (of which 1 included 2 comparisons), resulting in 27 comparisons of alternative staffing strategies. Twenty studies focused on a single ICU.

Data Synthesis We grouped ICU physician staffing into low-intensity (no intensivist or elective intensivist consultation) or high-intensity (mandatory intensivist consultation or closed ICU [all care directed by intensivist]) groups. High-intensity staffing was associated with lower hospital mortality in 16 of 17 studies (94%) and with a pooled estimate of the relative risk for hospital mortality of 0.71 (95% confidence interval [CI], 0.62-0.82). High-intensity staffing was associated with a lower ICU mortality in 14 of 15 studies (93%) and with a pooled estimate of the relative risk for ICU mortality of 0.61 (95% CI, 0.50-0.75). High-intensity staffing reduced hospital LOS in 10 of 13 studies and reduced ICU LOS in 14 of 18 studies without case-mix adjustment. High-intensity staffing was associated with reduced hospital LOS in 2 of 4 studies and ICU LOS in both studies that adjusted for case mix. No study found increased LOS with high-intensity staffing after case-mix adjustment.

Conclusions High-intensity vs low-intensity ICU physician staffing is associated with reduced hospital and ICU mortality and hospital and ICU LOS.

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Approximately 1% of the US gross domestic product is consumed in the care of intensive care unit (ICU) patients.[1] Despite this considerable investment of resources, there is wide variation in ICU organization,[2,3] and studies have suggested that differences in ICU organization may affect patient outcome. For example, staffing ICUs with critical care physicians (intensivists) may improve clinical outcomes.[4] A conceptual model that explains this finding is that physicians who have the skills to treat critically ill patients and who are immediately available to detect and treat problems may prevent or attenuate morbidity and mortality.[2] Staffing ICUs with intensivists may also decrease resource use because these physicians may be better at reducing inappropriate ICU admissions, preventing complications that prolong length of stay (LOS), and recognizing opportunities for prompt discharge.[2]

Intensive care unit staffing is typical of an organizational issue in health care in that, despite its potential importance in clinical and economic outcomes, it is not studied by using randomized trials. For example, the widely

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held belief that outcomes are better after surgery performed by experienced surgeons or hospitals is based solely on observational data.[5] Practical and ethical reasons exist to explain why such organizational characteristics are not subjected to randomized trials. Yet, as changes occur in the way health care is organized, financed, and delivered, it will be important to understand the impact of organizational characteristics, such as ICU physician and nurse staffing, on patient outcomes through systematic reviews.[6] To inform health policy, we will need to synthesize evidence that is predominantly observational. Accordingly, the goal of this systematic review was to examine the effect of ICU physician staffing on hospital and ICU mortality and LOS.

METHODS

Study Selection Criteria

We sought to identify and review all studies that met the following criteria: randomized or observational controlled trials of critically ill adults or children, ICU physician staffing strategies, hospital and ICU mortality, and LOS.

Citation Search Strategy

To identify literature in electronic databases, we searched MEDLINE from January 1, 1965, through September 30, 2001, by using the following medical subject heading (MeSH) terms: *intensive care units, ICU, health resources/utilization, hospitalization, medical staff, hospital organization and administration, personnel staffing and scheduling, length of stay*, and *LOS*. We used the following text words: *staffing, intensivist, critical, care,* and *specialist.* We used the search strategy for retrieval of controlled clinical trials proposed by Robinson and Dickersin.[7] To identify observational studies, we added the MeSH terms *case-control study* and *retrospective study*.

We also searched EMBASE, HealthStar (Health Services, Technology, Administration, and Research), and HSRPROJ (Health Services Research Projects in Progress) via Internet Grateful Med and The Cochrane Library (1998, issue 3), which contains the CENTRAL Database of Controlled Trials, the Database of Abstracts of Review Effectiveness, and the Cochrane Database of Systematic Reviews.

In addition, we used the *related articles* feature of PubMed, which identifies related articles by using a hierarchical search engine that is not solely based on MeSH headings. This search was completed with articles selected by 2 of the authors (P.J.P. and D.C.A.).[8-12] Although we searched for non–English-language citations, subsequent article review involved only English-language publications. To identify studies published in abstract form only, we hand-searched the abstract proceedings from the annual scientific assemblies of the Society of Critical Care Medicine, the American College of Chest Physicians, and the American Thoracic Society from January 1, 1994, through December 31, 2001.

Study Selection

After all citations based on our search strategy were identified, 2 of the authors (P.J.P. and D.C.A.) independently reviewed each abstract to confirm eligibility. If an abstract was selected as eligible, the same authors independently reviewed the respective article, if available, to confirm that it met inclusion criteria. Abstracts from meeting proceedings were included if the data were not published as peer-reviewed articles. To resolve discrepancies, the 2 reviewers either had to reach consensus, or use a third reviewer (T.D.).

Data Extraction

Using a data collection form, we extracted data from the studies to describe patient characteristics, study methods, and study findings. We also abstracted quantitative data regarding the intervention, cointerventions, study design and duration, unit of analysis, risk adjustment, degree of follow-up, adjustment of historical trends, and type of ICU. All data were abstracted independently by each of the 2 primary reviewers and verified for accuracy by the third reviewer, again with discussion used to resolve differences among reviewers. All reviewers were intensivists with formal training in clinical epidemiology and biostatistics. We did not mask the reviewers to author, institution, or journal because such masking reportedly makes little difference to the results of a systematic review.[13]

Data Synthesis and Analysis

We measured the percentage of agreement before discussion among reviewers in study selection, study design, and data abstraction. For data synthesis, we constructed evidence tables to present data separately for the 4 main outcome variables: hospital mortality, ICU mortality, hospital LOS, and ICU LOS. Because of wide variation in the methods used to evaluate hospital costs, we did not include cost as an outcome.

We classified the study design as a randomized clinical trial, cohort study (prospective, retrospective, or historical control), case-control study, or outcomes study (cross-sectional). We classified the method of risk adjustment as follows: validated physiologic method (discrimination and calibration of the model previously reported), selected clinical data (discrimination and calibration of the model not reported), and no risk adjustment.

Because ICU physician staffing varied widely among studies in the control and intervention groups, we initially classified ICU physician staffing as follows: (1) closed ICU (the intensivist is the patient's primary attending physician), (2) mandatory critical care consultation (the intensivist is not the patient's primary attending physician, but every patient admitted to the ICU receives a critical care consultation), (3) elective critical care consultation (the intensivist is involved in the care of the patient only when the attending physician requests a consultation), and (4) no critical care physician (intensivists were unavailable). Because it is difficult to distinguish between a closed ICU and a mandatory critical care consultation, and because in several studies we were not able to do so, we further grouped ICU physician staffing into high intensity (mandatory intensivist consultation or closed ICU) or

Table 1. Characteristics of Reviewed Studies Concerning ICU Physician Staffing and Outcomes*

				High Intensity†		Low Intensity†		
Source	Population	Study Design	ICUs Studied, No.	Patients, No.	Physician Staffing	Patients, No.	Physician Staffing	Outcome Measures
Pronovost et al,[2] 1999	Surgical (AAA repair)	Outcomes CS	39	2036	MC	472	EC	Hospital mortality, hospital and ICU LOS, rates of complications
Brown and Sullivan,[8] 1989	Medical or surgical	Cohort HC	1	216	CU	223	NI	Hospital and ICU mortality
Baldock et al,[9] 2001	Medical or surgical	Cohort HC	1	330	CU	295	EC	Hospital mortality
Kuo et al,[10] 2000	Surgical	Cohort HC	1	491	CU or MC	176	NI or EC	ICU mortality, ICU LOS
Multz et al,[11] 1998 (retrospective)	Medical	Cohort HC	1	154	CU	152	EC	Hospital mortality, hospital and ICU LOS, non-ICU LOS, procedure use, duration of MV
Multz et al,[11] 1998 (prospective)	Medical	Cohort CC	2	185	CU	95	EC	Hospital mortality, hospital and ICU LOS, non-ICU LOS, procedure use, duration of MV
Reynolds et al,[12] 1988	Medical (sepsis)	Cohort HC	1	112	CU or MC	100	NI	Hospital mortality, hospital and ICU LOS, hospital costs, discharge status, LOS by survivorship, No. of interventions, No. of consultations
Al-Asadi et al,[27] 1996‡	Medical	Cohort HC and CC	2	1005	CU	1404	EC	ICU mortality
Carson et al,[28] 1996	Medical	Cohort HC	1	121	CU	124	MC	Hospital mortality, hospital and ICU LOS, hospital costs, duration of MV, subgroup analysis, patient and family perceptions
Ghorra et al,[29] 1999	Surgical	Cohort HC	1	149	CU	125	EC	ICU mortality, ICU LOS, 30-day mortality, complications with procedure use
Li et al,[30] 1984	Medical or surgical	Cohort HC	1	517	CU	480	NI	Hospital mortality, ICU LOS, 1-year mortality, tests, monitoring, post-ICU LOS
Jacobs et al,[31] 1998‡	Surgical	Cohort HC	1	1108	CU	1051	EC or NI	ICU bed use efficiency, ICU readmission
Manthous et al,[32] 1997	Medical	Cohort HC	1	930	EC	459	NI	Hospital and ICU mortality, hospital and ICU LOS
Marini et al,[33] 1995‡	Surgical	Cohort HC	1	112	CU	65	EC	ICU mortality, ICU LOS, duration of MV, No. of consultations
Pollack et al,[34] 1988	Pediatric	Cohort HC	1	113	MC	149	NI	ICU mortality, ICU LOS, admission criteria, difference of case mix, TISS
Reich et al,[35] 1998‡	Medical or surgical	Cohort HC	1	830	CU	826	NI	ICU mortality, PA catheter use, No. of patients requiring MV, nursing hours per patient
Tai et al,[36] 1998	Medical	Cohort HC	1	127	CU	112	NI	ICU mortality, hospital and ICU LOS, PA catheter use, arterial catheter use, readmissions
Pollack et al,[37] 1994	Pediatric	Outcomes CS	16	2606	MC	2809	NI	Hospital and ICU mortality
DiCosmo,[38] 1999‡	Medical	Cohort HC	1	1292	MC	1667	EC	ICU mortality, ICU LOS, LOS with MV, MV mortality
Dimick et al,[39] 2001	Surgical (esophagectomy)	Outcomes CS	35	182	MC	169	EC	Hospital mortality, hospital LOS, hospital costs, postoperative complications

(continued)

Table 1. Characteristics of Reviewed Studies Concerning ICU Physician Staffing and Outcomes* (cont)

Source	Population	Study Design	ICUs Studied, No.	High Intensity† Patients, No.	High Intensity† Physician Staffing	Low Intensity† Patients, No.	Low Intensity† Physician Staffing	Outcome Measures
Dimick et al,[40] 2000‡	Surgical (hepatectomy)	Outcomes CS	NR	276	MC	275	EC	Hospital mortality, hospital LOS, hospital costs
Rosenfeld et al,[41] 2000	Surgical	Cohort HC	1	201	MC§	225	EC	Hospital and ICU mortality, hospital and ICU LOS, complications, ICU and hospital costs
Diringer and Edwards,[42] 2001	Neurological (intracerebral hemorrhage)	Outcomes CS	42	266	CU	772	EC	Hospital mortality, hospital and ICU LOS
Goh et al,[43] 2001	Pediatric	Cohort HC	1	355	CU	264	EC	ICU mortality, ICU LOS
Blunt and Burchett,[44] 2000	Medical	Cohort HC	1	393	CU	328	EC	Hospital mortality, hospital and ICU LOS
Topeli,[45] 2000‡	Medical	Cohort HC	1	149	CU	200	NI	ICU mortality, MV mortality
Hanson et al,[46] 1999	Surgical	Cohort CC	1	100	MC	100	NI	Hospital mortality, hospital and ICU LOS, hospital costs

*All studies were observational and control groups varied. ICU indicates intensive care unit; AAA, abdominal aortic surgery; CS, cross-sectional with concurrent control; MC, mandatory critical care consultation; EC, elective critical care consultation; LOS, length of stay; HC, historical control; CU, closed unit; NI, no intensivist; MV, mechanical ventilatory support; CC, concurrent control; TISS, Therapeutic Intervention Scoring System; PA catheter, pulmonary artery (Swan-Ganz) catheter; and NR, not reported.
†High-intensity physician staffing is either mandatory intensivist consultation or closed ICU. Low-intensity physician staffing is either no intensivist or elective intensivist consultation.
‡An abstract was reviewed; in all other instances, full journal articles were considered.
§Intervention was remote ICU management (telemedicine) using videoconferencing.

low intensity (no intensivist or elective intensivist consultation).

Evaluation of Study Quality

We elected to evaluate study quality as the risk of bias caused by temporal trends, confounding, and incomplete follow-up. We classified the risk of bias caused by temporal trends as low if the study duration was shorter than 2 years, medium if 2 through 4 years, and high if longer than 4 years. We classified the risk of bias from confounding as low if the authors used a validated physiologic method of risk adjustment, medium if the authors used selected clinical data, and high if the authors used no risk adjustment. We classified the risk of bias from incomplete follow-up as low if it was 90% to 100% complete; medium for 80% to 89% complete; and high for less than 80% complete.

Data Analysis

Because the studies varied markedly in design, risk adjustment method, and ICU physician staffing in the control and intervention groups, we performed a qualitative and quantitative assessment of heterogeneity among trials. Because we considered the qualitative heterogeneity among studies to be significant, we were reluctant to perform a quantitative synthesis of study results.[14] Nevertheless, we used the test for quantitative heterogeneity.[15,16] We present a random-effects, summary relative risk (RR) by using the methods of DerSimonian.[17] When the data were available, we summarized mortality data from each study with RRs, odds ratios (ORs), and estimated 95% confidence intervals (CIs) for the ORs by using Woolf's method.[18] We summarized LOS data as a relative reduction. We evaluated for publication bias with a funnel plot. All statistical calculations were performed with STATA 7.0 statistical software (STATA Corp, College Station, Tex). When possible, we reported unadjusted and adjusted outcomes for baseline severity of illness. When absolute rates of hospital mortality were unavailable, we reported the observed-expected mortality rate, and when the SD of LOS data were unavailable, we assumed it to be equal to the mean.[2] We used mean rather than median LOS because few studies reported medians. Results were considered significant at *P*<.05.

RESULTS

Study Selection and Characteristics

We identified 3544 citations from the electronic search, of which 660 were duplicates and 294 were unavailable in English and were excluded. We also identified 13 citations from hand searching meeting proceedings. Of the 2590 abstracts reviewed, we rejected 2556 (99%) because the intervention was not ICU physician staffing or because the published abstract was superseded by the subsequent article. We rejected an additional 8 abstracts after reviewing and discussing the corresponding article because the intervention was not ICU physician staffing or because the reviewers were not able to determine the type of ICU physician staffing.[19-26] Twenty-six studies[2,8-12,27-46] met selection criteria (19 articles and 7 published abstracts). The reviewers had 99% crude agreement in the selection of eligible abstracts and 96% crude agreement in the selection of eligible articles (TABLE 1). FIGURE 1[47] presents the study search strategy (QUOROM: Quality of Reporting of Meta-analyses).

Twenty studies (77%) were from North America,[a] 3 (12%) were from Eu-

[a]References 2, 8, 11, 12, 27-29, 30-35, 37-42, 46.

rope,[9,44,45] and 3 (12%) were from Asia.[10,36,43] Eleven (42%) were from academic medical centers,[b] 6 (23%) were from community teaching hospitals,[11,27,32,33,36,41] 4 (15%) were from nonteaching community hospitals,[30,35,38,44] and 5 (19%) included a variety of hospitals[2,37,39,40,42] (3 studies included all hospitals in Maryland[2,39,40]). One article included a prospective and retrospective control arm.[11] Because our goal was to describe the available literature, we treated this article as 2 studies and thus had 27 studies for qualitative synthesis (Table 1).

Table 1 summarizes important aspects of these 27 studies, which included ICU patients treated between 1979 and 2000. Study populations included medical patients in 11 studies (41%),[c] surgical patients in 9 (33%),[2,10,29,31,33,39-41,46] mixed medical and surgical patients in 4 (15%),[8,9,30,35] and pediatric patients in 3 (11%).[34,37,43] Sample sizes varied from 177 to 5415 patients, with a mean sample size of 1001 patients (SD, 1190) and a median sample size of 551 patients (25%-75% interquartile range, 277-1213).

Study Design

All of the studies used an observational design (Table 1). Twenty-two were cohort studies, with 19 using historical controls (before-and-after design),[d] 2 using concurrent controls,[11,46] and 1 using both.[27] Five studies were cross-sectional with concurrent controls.[2,37,39,40,42] In one study, the ICU physician staffing in the intervention group was via remote videoconferencing.[41] Twenty of the studies evaluated a single ICU,[e] 2 evaluated 2 ICUs,[11,27] 1 evaluated 16 ICUs,[37] 1 evaluated 35 ICUs,[39] 1 evaluated 39 ICUs,[2] 1 evaluated 42 ICUs,[42] and 1 did not report the number of ICUs evaluated.[40]

ICU Physician Staffing

Twenty-five studies compared high- with low-intensity ICU physician staffing. Of the remaining 2, one compared a closed ICU with a mandatory consultation[28] and the other compared elective consultation with no intensivist involved.[32] Of the 25 studies comparing high- with low-intensity staffing, 9 compared a closed ICU (intervention group) with elective consultation (control group),[9,11,27,29,33,42-44] 3 compared mandatory consultation (intervention) with no intensivist (control),[34,37,46] 5 compared mandatory consultation (intervention) with elective consultation (control group),[2,38-41] and 5 compared closed ICU (intervention) with no intensivist (control).[8,30,35,36,45] In 2 studies, we could not differentiate between a closed ICU and a mandatory consultation,[10,12] and in 2 studies[10,31] we could not differentiate between an elective consultation and no intensivist.

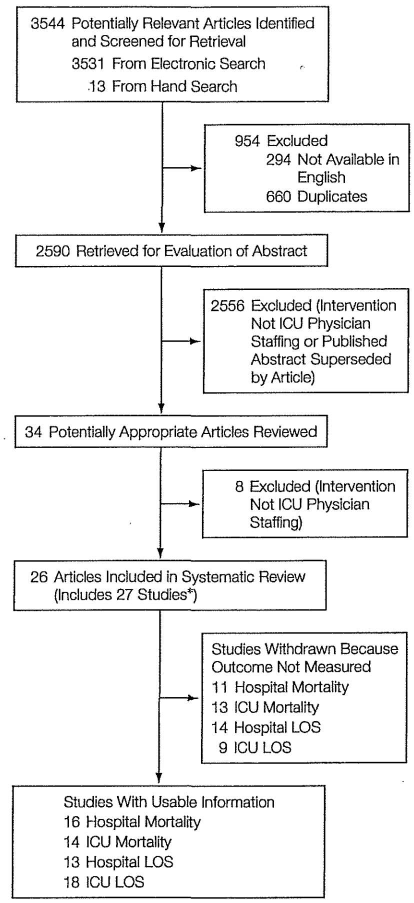
Quality Characteristics

The quality characteristics of the studies are listed in TABLE 2. Fifteen of the 24 studies that reported the study period had low risk of bias from temporal trends, whereas 8 studies had medium risk and 1 had high risk. All 27 studies had complete follow-up and thus a low risk of bias from incomplete follow-up. No study followed up patients after hospital discharge.

Twenty-one of 27 studies had low risk of bias from confounding, whereas 6 studies had medium risk. All studies reported some form of risk adjustment. Twenty-one studies used a validated physiologic method (15 used the Acute Physiology and Chronic Health Evaluation Score [APACHE] only,[48,49] 2 used the Mortality Prediction Model,[50] 2 used the Pediatric Risk of Mortality Score,[51,52] 1 used the Physiologic Severity Index [PSI],[53] and 1 reported both APACHE II and the Glasgow Coma Scale[54]). Six studies used selected clinical data (the first used nursing hours per patient,[35] a second used age, reason for admission, and mental status,[30] a third used a customized case-mix index and patient acuity measured by percentage of patients requiring mechanical ventilatory support,[38] and 3 others used discharge data in a regression model to adjust for patient demographics, severity of illness, comorbid disease, and hospital and surgeon volume[2,39,40]) (Table 1).

Eleven studies reported differences in severity of illness between the high- and low-intensity groups. In 4 studies,[28,31,45,46] the high-intensity group compared with the low-intensity group had significantly higher APACHE scores, suggesting higher baseline severity of illness. Three studies reported higher severity in the low-intensity group by using different severity instruments.[42-44] Two studies reported higher baseline severity in the high-intensity group by using the distribution of the PSI score[34] and APACHE II score.[10] Another study reported higher ICU nursing hours per day and suggested that this represented

Figure 1. Study Flow Diagram



ICU indicates intensive care unit; LOS, length of stay. The asterisk indicates that the article by Multz et al[11] had 2 comparisons (retrospective and prospective).

[b]References 8-10, 12, 28, 29, 31, 34, 43, 45, 46.
[c]References 11, 12, 27, 28, 32, 36, 38, 42, 44, 45.
[d]References 8-12, 28, 29, 30-36, 38, 41, 43-45.
[e]References 8-12, 28, 29, 30-36, 38, 41, 43-46.

higher severity in the high-intensity physician staffing group.[35] The author of the study,[38] which used patient acuity and case-mix index, also suggested greater severity in the arm with the high-intensity physician staffing. There was no evidence of publication bias on a funnel plot of hospital mortality (FIGURE 2).

Impact of High- vs Low-Intensity ICU Physician Staffing

Hospital Mortality. Seventeen studies (63%) reported hospital mortality according to ICU physician staffing as a primary outcome measure (TABLE 3). The hospital mortality rate ranged from 6% to 74% in the low-intensity staffing group and from 1% to 57% in the high-intensity staffing group (Table 3). Overall, 16 (94%) of the 17 studies showed a decrease in hospital mortality rate for ICU patients with high-intensity physician staffing; in the one study that showed increased mortality with high-intensity physician staffing, the increase was not statistically significant.[28] In 10 (67%) of 15 studies[2,8,9,12,32,39-42,44] that reported unadjusted mortality and 9 (64%) of 14 studies[f] that reported adjusted mortality, the decrease was statistically significant (Table 3). No study reported a statistically significant increase in hospital mortality with high-intensity ICU physician staffing. The random-effects pooled estimate of the unadjusted RR for high-intensity vs low-intensity staffing is 0.71 (95% CI, 0.62-0.82) (FIGURE 3A).

ICU Mortality. Fifteen studies (56%) evaluated the impact of ICU physician

[f]References 2, 8, 12, 30, 32, 37, 40, 41, 44.

Table 2. Quality Characteristics of Reviewed Studies*

Source	Study Period	Risk for Bias Due to Temporal Trends	Adjustment for Confounding Variables	Risk for Bias Due to Confounding Variables
Pronovost et al,[2] 1999	1994-1996	Low	†	Medium
Brown and Sullivan,[8] 1989	1984-1986	Low	APACHE II	Low
Baldock et al,[9] 2001	1995-1998	Medium	APACHE II	Low
Kuo et al,[10] 2000	1986-1996	High	APACHE II	Low
Multz et al,[11] 1998 (retrospective)	1992-1993	Low	MPM	Low
Multz et al,[11] 1998 (prospective)	1992-1993	Low	MPM	Low
Reynolds et al,[12] 1988	1982-1984	Low	APACHE II	Low
Al-Asadi et al,[27] 1996‡	1991-1995	Medium	APACHE II	Low
Carson et al,[28] 1996	1993-1994	Low	APACHE II§	Low
Ghorra et al,[29] 1999	1995-1996	Low	APACHE III	Low
Li et al,[30] 1984	1979-1981	Low	Age, reason for admission, mental status	Medium
Jacobs et al,[31] 1998‡	1995-1997	Low	APACHE III§	Low
Manthous et al,[32] 1997	1992-1994	Low	APACHE II	Low
Marini et al,[33] 1995‡	1993-1994	Low	APACHE II	Low
Pollack et al,[34] 1988	1983-1984	Low	PSI§	Low
Reich et al,[35] 1998‡	Not stated		Nursing hours per day§	Medium
Tai et al,[36] 1998	1993-1994	Low	APACHE II	Low
Pollack et al,[37] 1994	1989-1992	Medium	PRISM	Low
DiCosmo,[38] 1999‡	1994-1997	Medium	†	Medium
Dimick et al,[39] 2001	1994-1998	Medium	†	Medium
Dimick et al,[40] 2001‡	1994-1998	Medium	†	Medium
Rosenfeld et al,[41] 2000	1996-1997	Low	APACHE III	Low
Diringer and Edwards,[42] 2001	1996-1999	Medium	APACHE II§ Glasgow Coma Scale§	Low
Goh et al,[43] 2001	1996-1997, 1999-2000	Medium	PRISM II	Low
Blunt and Burchett,[44] 2000	Not stated		APACHE II§	Low
Topeli,[45] 2000‡	Not stated		APACHE II§	Low
Hanson et al,[46] 1999	1994-1995	Low	APACHE II§	Low

*Risk of bias due to temporal trends is classified as low if study duration was 2 years or less, medium if 2 to 4 years, and high if more than 4 years. Risk of bias from confounding is classified as low if validated physiologic method of risk adjustment was used, medium if selected clinical data were used, and high if no risk adjustment was used. Risk of bias from incomplete follow-up is classified as low if follow-up is 90% to 100% complete, medium if follow-up is 80% to 89%, and high if less than 80%. Risk for bias due to incomplete follow-up was low in all studies. APACHE indicates Acute Physiology and Chronic Health Evaluation Score; MPM, Mortality Prediction Model; PSI, Physiologic Severity Index; and PRISM, Pediatric Risk of Mortality.

†Patient demographics (age, sex, race), comorbidity (diseases in Romano-Charlson index) for the study by Pronovost et al,[2] severity of illness (urgent or emergent admission, ruptured aorta for the study by Pronovost et al[2]; case-mix index for the study by DiCosmo[38] and the 2 studies by Dimick et al[39,40]; percentage of patients requiring mechanical ventilation for the study by DiCosmo[38]), hospital volume, and surgeon volume for the study by Pronovost et al[2] and the 2 studies by Dimick et al.[39,40] These studies reported the distribution of severity scores by subgroups rather than the means for the low-intensity and high-intensity groups. Pollack et al[34] reported statistical difference between the low-intensity and high-intensity groups, whereas distributions were comparable in the study by Kuo et al.[10]

‡Abstract was reviewed; in all other instances, full journal articles were considered.

§Statistically significant difference ($P<.05$) in severity of illness (as defined by the risk adjustment methods used) between intervention and control groups.

staffing on ICU mortality, with 12 studies (80%) reporting ICU mortality adjusted for severity of illness (Table 3). Overall, 14 (93%) of these 15 studies[g] showed a decrease in ICU mortality rate for ICU patients with high-intensity physician staffing. Nine (69%) of the 13 studies[8-10,29,32,35,38,41,43] that reported unadjusted ICU mortality rates found a statistically significant reduction with high-intensity physician staffing in the ICU (Figure 3B and Table 3). In 9 (75%) of the 12 studies[8-10,29,32,34,35,41,43] that adjusted for severity of illness, ICU mortality significantly decreased as well with high-intensity physician staffing. The random-effects, pooled estimate of the unadjusted RR for high-intensity vs low-intensity staffing is 0.61 (95% CI, 0.50-0.75).

Hospital LOS. Thirteen studies (48%) evaluated the impact of ICU physician staffing on hospital LOS (TABLE 4). The hospital LOS ranged from 8 to 33 days in the low-intensity group and 7 to 24 days in the high-intensity group. Ten (77%) of 13 studies reported a reduction in hospital LOS with high-intensity staffing (range of relative reduction, 5%-42%).[h] In 6 of these studies, the reduction was statistically significant (FIGURE 4A).[2,11,32,39,46] Only 1 study (8%) reported a statistically significant increase in hospital LOS with high-intensity physician staffing, but this study compared patients admitted to a neurosurgical ICU with patients admitted to a general ICU, and the results were not adjusted for baseline severity of illness.[42] Only 4 studies adjusted hospital LOS for baseline severity of illness.[2,39-41] Two of these studies[2,39] showed a statistically significant decrease in hospital LOS with high-intensity physician staffing in the ICU, with the remaining 2 studies[40,41] showing no significant difference in hospital LOS.[39]

Intensive Care Unit LOS. Eighteen studies (67%) evaluated the impact of ICU physician staffing on ICU LOS (Table 4). The ICU LOS ranged from 2 to 13 days in the low-intensity group and 2 to 10 days in the high-intensity group. Fourteen (78%) of 18 studies reported that ICU LOS decreased with high-intensity physician staffing (Figure 4B).[i] In 11 of these studies, this decrease was statistically significant.[j] The study that compared a closed neurosurgical ICU to a general ICU was the only one to report a statistically significant increase in ICU LOS with high-intensity ICU physician staffing in the neurosurgical ICU.[42] Three of 18 studies reported higher severity in the high-intensity group,[28,38,46] 2 reported higher severity in the low-intensity group,[43,44] and the remaining 13 reported no difference between the 2 groups.[k] Only 2 studies adjusted ICU LOS for baseline severity of illness[2,42]; ICU LOS in both studies favored high-intensity physician staffing.

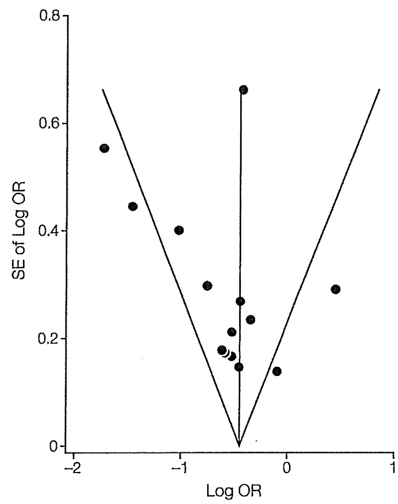
COMMENT

We found that greater use of intensivists in the ICU led to significant reductions in ICU and hospital mortality and LOS. These findings were consistent across a variety of populations and hospital settings and have potentially important implications for patient care. Given the variation in ICU physician staffing and the potential for reduced mortality implied by these studies, a more rigorous evaluation of the optimal ICU organization is essential.

Intensive care is one of the largest and most expensive aspects of US health care. There are approximately 6000 ICUs in the United States,[55] caring for approximately 55 000 patients daily,[55] with an annual budget of approximately $180 billion.[1] The proportion of ICUs with high-intensity ICU physician staffing is unclear, but appears to be relatively small. In 1992, Groeger et al[3] suggested that only 10% of ICUs in the United States require an intensivist to act as the patients' primary physician. In 1999, Schmitz et al[55] estimated that one third of all ICU patients in the United States were treated by intensivists acting as either primary physicians or consultants. Since most ICU patients are cared for with low-intensity physician staffing and high-intensity staffing appears to be associated with improved outcomes, mandatory ICU physician staffing may improve ICU process and outcomes.

The general lack of intensivist staffing in the United States contrasts with the usual closed ICU approach in Europe and Australia. A survey[56] by the Audit Commission for Local Authorities and the National Health Service in England and Wales found that closed systems are common and intensivists initiate care in 80% of all ICUs. The average 6-bed general ICU in the United Kingdom has 3 consultants with fixed commitments to the unit and 3 more taking part in the on-call rota.[56] According to Cole et al,[57] all ICUs in Victoria, the second most populous state in Australia, have been following the closed model for more than a decade. In 1997, a task force of the European Society of Intensive Care Medicine[58] issued recommendations on minimal requirements for intensive care departments (ICDs). Although the recommendations were not

Figure 2. Funnel Plot of Hospital Mortality



The funnel plot provides an estimate of publication bias. In the absence of bias, the studies should be symmetrically distributed along the funnel. If small studies with negative results are unpublished, the plot will appear asymmetrical. Our plot suggests no evidence of publication bias. Log OR indicates log odds ratio.

[g]References 8-10, 27, 29, 31-36, 38, 41, 43.
[h]References 2, 11, 28, 32, 36, 39, 40, 44, 46.
[i]References 2, 10, 11, 29, 30, 32, 33, 36, 38, 41, 43, 44, 46.
[j]References 2, 10, 11, 32, 33, 36, 38, 41, 43, 46.
[k]References 2, 10-12, 29, 30, 32-34, 36, 41, 42.

evidence based, the task force emphasized that the director of an ICD should be an intensivist and that it is essential that a qualified intensivist provide 24-hour coverage in level II and III (moderate- and high-intensity care) ICDs.[58] The task force also recommended 24-hour coverage by an intensivist for level I ICDs.[58]

Our review identified several issues that may be important for researchers studying health care organizational characteristics. Our initial search, based on MeSH terms and text words, yielded a large number of citations, yet failed to identify several relevant articles that we had previously identified.[8,9,11,12,28,30,32,34] Although each shared *intensive care unit* as a MeSH term, the assignment of other MeSH terms was inconsistent. By incorporating the related articles feature, we were able to identify additional relevant articles. The configuration of MeSH terms is not ideal for a comprehensive review of health care organizational characteristics, and investigators and library scien-

Table 3. Hospital and ICU Mortality With Low- and High-Intensity ICU Physician Staffing*

Source	No./Total (%) of Deaths: Low-Intensity ICU Staff	No./Total (%) of Deaths: High-Intensity ICU Staff	OR (95% CI)†	*P* Value: Unadjusted	*P* Value: Adjusted‡
		Hospital Mortality			
Pronovost et al,[2] 1999	52/472 (21)	131/2036 (6)	0.56 (0.40-0.78)	<.05	<.05
Brown and Sullivan,[8] 1989	79/223 (36)	53/216 (25)	0.59 (0.39-0.90)	<.01	<.05
Baldock et al,[9] 2001§	107/294 (36)	78/330 (24)	0.54 (0.38-0.77)	<.001	NR
Multz et al,[11] 1998 (retrospective)	68/152 (45)	56/154 (36)	0.71 (0.47-1.12)	NS	NS‖
Multz et al,[11] 1998 (prospective)	36/95 (38)	52/185 (28)	0.64 (0.38-1.08)	NS	NS‖
Reynolds et al,[12] 1988	74/100 (74)	64/112 (57)	0.47 (0.26-0.83)	<.01	<.05
Carson et al,[28] 1996	28/124 (23); O/E, 0.9¶	38/121 (31); O/E, 0.8¶	1.57 (0.89-2.78); O/E, 0.89¶	.12	NR
Li et al,[30] 1984	153/480 (32)	154/517 (30)	0.91 (0.69-1.19)	NS	.01
Jacobs et al,[31] 1998§	O/E, 0.98¶	O/E, 0.81¶	O/E, 0.83¶	NR	NS
Manthous et al,[32] 1997	156/459 (34)	116/471 (25)	0.63 (0.48-0.84)	.002	<.05
Pollack et al,[37] 1994	. . .	. . .	. . .	NR	.03
Dimick et al,[39] 2001	24/169 (14)	7/182 (4)	0.24 (0.10-0.58)	.003	NS
Dimick et al,[40] 2001	21/275 (8)	4/276 (1)	0.18 (0.05-0.50)	<.001	<.05
Rosenfeld et al,[41] 2000	26/225 (12); O/E, 1.1¶	9/201 (5); O/E, 0.7¶	0.36 (0.16-0.79)	.008	<.05
Diringer and Edwards,[42] 2001	. . .	. . .	0.39 (0.22-0.67)	.001	NR
Blunt and Burchett,[44] 2000	113/328 (34); O/E, 1.1¶	93/393 (24); O/E, 0.8¶	0.59 (0.43-0.82)	.001	<.05
Hanson et al,[46] 1999	6/100 (6)	4/100 (4)	0.65 (0.18-2.39)	NS	NS
		ICU Mortality			
Brown and Sullivan,[8] 1989	62/223 (28)	29/216 (13)	0.40 (0.25-0.66)	<.01	<.05
Baldock et al,[9] 2001§	83/294 (28)	64/330 (19)	0.61 (0.42-0.89)	.01	.005
Kuo et al,[10] 2000	90/176 (51)	151/491 (31)	0.42 (0.30-0.60)	<.001	<.01
Al-Asadi et al,[27] 1996	112/1404 (8)	66/1005 (7)	0.81 (0.59-1.11)	.19	NS
Ghorra et al,[29] 1999	18/125 (14)	9/149 (6)	0.38 (0.17-0.88)	.01	<.05
Jacobs et al,[31] 1998§	O/E, 1.17¶	O/E, 0.99¶	O/E, 0.85¶	NR	NS
Manthous et al,[32] 1997	96/459 (21)	70/471 (15)	0.66 (0.47-0.93)	.02	<.05
Marini et al,[33] 1995§	13/65 (20)	12/112 (11)	0.48 (0.21-1.13)	.09	NR
Pollack et al,[34] 1988	10/149 (7)	4/113 (4)	0.51 (0.16-1.67)	.26	<.05
Reich et al,[35] 1998	57/826 (7)	35/830 (4)	0.59 (0.39-0.92)	<.05	<.05
Tai et al,[36] 1998#	O/E, 1.23¶	O/E, 1.0¶	. . .	NR	.29
DiCosmo,[38] 1999	137/1667 (8.2)	63/1292 (4.9)	0.57 (0.42-0.78)	<.001	NR
Rosenfeld et al,[41] 2000	22/225 (10); O/E, 1.8¶	3/201 (2); O/E, 0.6¶	0.14 (0.04-0.48)	<.01	<.05
Goh et al,[43] 2001	82/264 (31); O/E, 0.9¶	42/355 (12); O/E, 1.6¶	0.30 (0.20-0.45)	<.001	<.05
Topeli,[45] 2000	42/200 (21)	45/149 (30)	1.63 (0.99-2.66)	.05	. . .

*ICU indicates intensive care unit; OR, odds ratio; CI, confidence interval; NR, not reported; and NS, not significant. Low ICU physician staffing is either no intensivist available or elective consultation; high ICU physician staffing is either mandatory consultation or closed ICU. Ellipses indicate studies in which outcome was not evaluated.
†The ORs are quoted from the studies or calculated from unadjusted high-intensity mortality rate vs low-intensity mortality rate where rates were available.
‡Results were adjusted for baseline severity of illness. Adjusted *P* values and ORs (where available) shown as reported by the authors.
§Studies have more than 1 observation period after intervention. Information from observation period closest to intervention is included.
‖Multz et al[11] also pooled the data and found a significant reduction in hospital mortality ($P<.04$) with high-intensity ICU physician staffing.
¶O/E is the observed-to-expected mortality ratio based on risk adjustment using the Acute Physiology and Chronic Health Evaluation Score (APACHE) II (studies by Carson et al,[28] Tai et al,[36] and Blunt and Burchett[44]), APACHE III (studies by Jacobs et al[31] and Rosenfeld et al[41]), or Pediatric Risk of Mortality II (study by Goh et al[43]).
#Data reported for survivors only.

tists should improve this indexing situation.

There are a number of potential limitations to consider regarding this literature. First, there is a risk of selection bias. Mark[59] describes 3 areas of possible selection bias in critical appraisal: selection of representative subjects (generalizability), selection of subjects to exposure (confounding variables), and selection of subjects at outcome (distorted samples). We believe the findings are generalizable because there was a consistent benefit associated with high-intensity staffing in studies of medical and surgical patients, studies from academic and community hospitals, and studies from inside and outside the United States. Because the studies are not randomized, the risk of confounding variables is considerable. However, an important strength of this literature was the consistent use of risk-adjustment methods. Critical care medicine has developed sophisticated, well-validated, risk-adjustment methods that use multiple clinical and physiologic variables to predict the risk of in-hospital death.[48-52] In our analysis, 22 (81%) of 27 studies used such methods to minimize bias from confounding variables. Finally, all 27 studies had complete follow-up, and there was therefore no risk of bias from distorted samples.

A second potential limitation is publication bias. However, the funnel plot suggested that risk for publication bias was not significant (Figure 2). There was no quantitative heterogeneity among studies, and the results were consistent across studies, increasing our confidence in the validity of our conclusions. Moreover, from our discussions with staff of critical care societies (American Thoracic Society, American College of Chest Physicians, and Society of Critical Care Medicine at their annual meetings during 1999-2001), we found no evidence of any relevant negative unpublished studies.

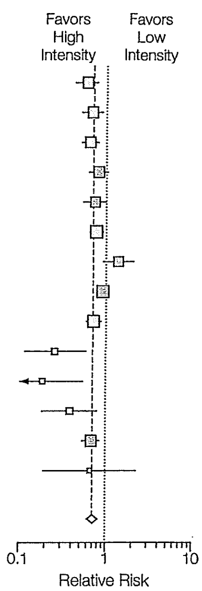
A third potential limitation is risk for temporal trends in mortality to bias study results. Temporal trends in any before-and-after study design could affect the results of this review and reduce the strength of our inferences. We believe this source of bias is small for several reasons. First, evidence for the effectiveness of therapies in reducing mortality in critically ill patients occurred only at the end of the study periods.[60-62] Second, there were no trends for reduced mortality in critically ill patients during the study periods. Third, most of the studies were conducted during a short period, and thus the effect of any temporal trends is likely small.

A fourth potential limitation is the use of ICU mortality and LOS as outcome measures. Because no study described explicit criteria for discharge from the ICU, differences in discharge practices between the treatment and control groups may have influenced the results. For example, early ICU discharge may have artificially reduced ICU mortality without decreasing hospital mortality. However, the improvement in mortality and LOS observed with high-intensity ICU physician staff-

Figure 3. Unadjusted Hospital and ICU Mortality With Low- and High-Intensity ICU Physician Staffing

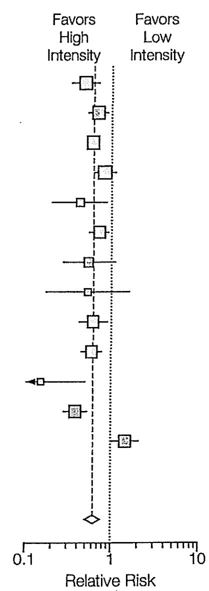
A Hospital Mortality

Source	Weight	Risk Ratio (95% CI)
Pronovost et al[2]	8.4	0.58 (0.43-0.79)
Brown and Sullivan[8]	8.6	0.69 (0.52-0.93)
Baldock et al[9]	9.7	0.65 (0.51-0.83)
Multz et al[11] (Retrospective)	9.0	0.81 (0.62-1.07)
Multz et al[11] (Prospective)	7.5	0.74 (0.53-1.05)
Reynolds et al[12]	10.7	0.77 (0.63-0.94)
Carson et al[28]	6.2	1.39 (0.91-2.11)
Li et al[30]	11.0	0.93 (0.78-1.13)
Manthous et al[32]	10.6	0.72 (0.59-0.89)
Dimick et al[39]	2.5	0.26 (0.12-0.59)
Dimick et al[40]	1.6	0.19 (0.07-0.55)
Rosenfeld et al[41]	2.9	0.39 (0.19-0.81)
Blunt and Burchett[44]	10.0	0.69 (0.54-0.87)
Hanson et al[46]	1.2	0.67 (0.19-2.29)
Overall (95% CI)		0.71 (0.62-0.82)



B ICU Mortality

Source	Weight	Risk Ratio (95% CI)
Brown and Sullivan[8]	8.4	0.48 (0.32-0.72)
Baldock et al[9]	10.0	0.69 (0.52-0.91)
Kuo et al[10]	11.3	0.60 (0.49-0.73)
Al-Asadi et al[27]	9.9	0.82 (0.61-1.10)
Ghorra et al[29]	4.4	0.42 (0.20-0.90)
Manthous et al[32]	10.1	0.71 (0.54-0.94)
Marini et al[33]	4.7	0.54 (0.26-1.10)
Pollack et al[34]	2.5	0.53 (0.17-1.64)
Reich et al[35]	8.2	0.61 (0.41-0.92)
DiCosmo[38]	10.0	0.59 (0.44-0.79)
Rosenfeld et al[41]	2.3	0.15 (0.05-0.50)
Goh et al[43]	9.3	0.38 (0.27-0.53)
Topeli[45]	8.9	1.44 (1.00-2.07)
Overall (95% CI)		0.61 (0.50-0.75)



Data from studies demonstrate the relative risk (RR) with 95% confidence intervals (CI) of hospital and intensive care unit (ICU) mortality with high intensity vs low intensity ICU physician staffing. The RRs less than 1 suggest reduced mortality with high intensity staffing while RRs greater than 1 suggest increased mortality with high intensity staffing. The size of the data markers corresponds to the weight of the studies. Larger markers imply less uncertainty from the results of the individual study, and carry more weight in calculating the random effects pooled estimate from the systematic review.

ing was observed at ICU and hospital discharge.

There are also limitations in the way we conducted our review. First, 3 of the authors (P.J.P., D.C.A., and T.D.) are intensivists and potentially biased. The high degree of agreement among reviewers may be due to similar clinical and research interests and may have encoded systematic error. Second, we included only articles published in English, although we are not aware of relevant non–English-language publications. The exclusion of non–English-language articles should not significantly affect the study results.[63] Third, we did not perform a formal evaluation of study quality, because the particular scale chosen may influence the results.[64] Rather, we identified relevant methodologic aspects of the study (a priori) and assessed these individually.

Our systematic review was rigorously conducted and transparently reported, following recommendations outlined by the Meta-analysis of Observational Studies in Epidemiology Group.[14] Because it is unclear how to proceed when there is qualitative but not quantitative heterogeneity among studies, we present pooled estimates by using the random-effects model and recommend cautious interpretation of these results.

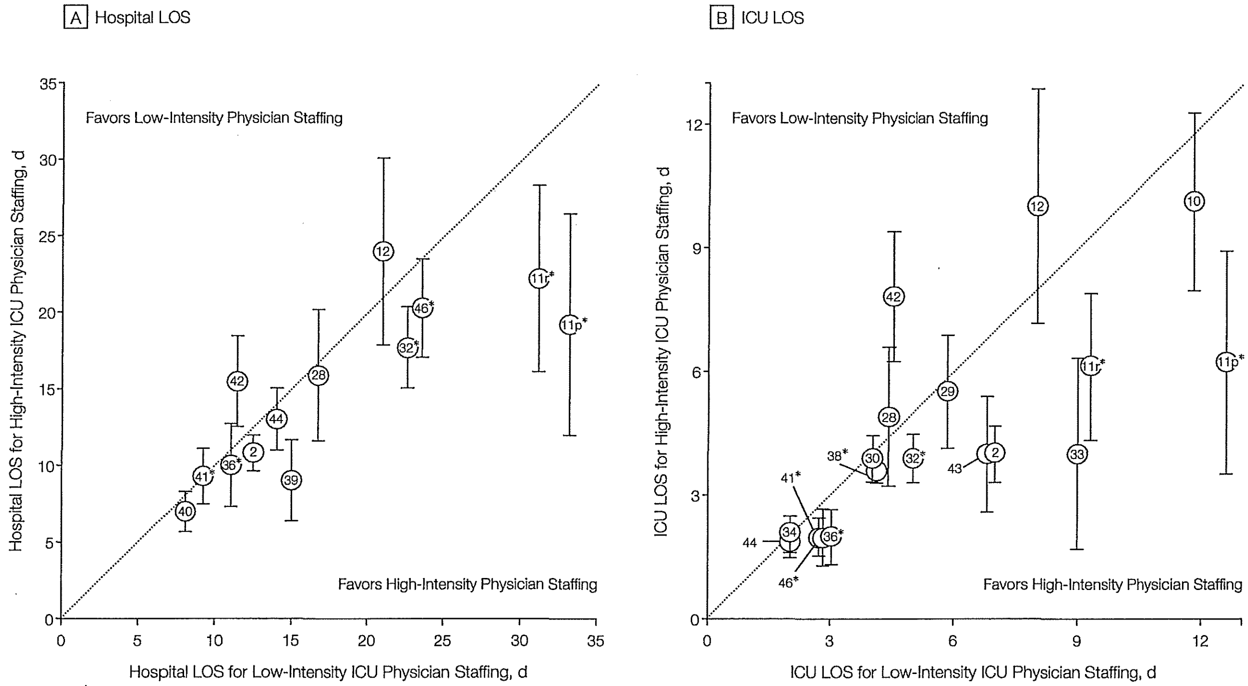
We should attempt to identify the characteristics of high-intensity ICU

Table 4. Hospital and ICU Length of Stay with Low- and High-Intensity ICU Physician Staffing*

Source	Length of Stay (LOS)		*P* Value		Relative Reduction in LOS, %
	Low-Intensity ICU Staff	High-Intensity ICU Staff	Unadjusted	Adjusted†	
Hospital LOS					
Pronovost et al,[2] 1999	12.5 (11.5)	10.8 (10.5)	<.05	<.05	14
Multz et al,[11] 1998 (retrospective)	31.2 (31.2)‡	22.2 (22.2)‡	<.02	NR	29
Multz et al,[11] 1998 (prospective)	33.2 (33.2)§	19.2 (19.2)‡	<.01	NR	42
Reynolds et al,[12] 1988	21 (22)	24 (23)	NS	NR	−14§
Carson et al,[28] 1996	16.7 (19.4)	15.9 (4.2)	.75	NR	5
Manthous et al,[32] 1997	22.6 (22.6)‡	17.7 (17.7)‡	<.05	NR	22
Tai et al,[36] 1998	11 (11)‡	10 (10)‡	NS	NR	9
Dimick et al,[39] 2001‖	15 (11-25)	9 (8-11)	<.05	<.05	40
Dimick et al,[40] 2001‖	8 (6-11)	7 (6-10)	NS	NS	13
Rosenfeld et al,[41] 2000	9.2 (9.2)‡ O/E 0.63	9.3 (9.3)‡ O/E 0.6	NS	NS	−1§
Diringer and Edwards,[42] 2001	11.4 (5.8)	15.5 (24.0)	<.05	NR	−36§
Blunt and Burchett,[44] 2000‖	14 (8-24)	13 (8-24)	NS	NR	7
Hanson et al,[46] 1999	23.6 (23.6)‡	20.3 (20.3)‡	<.05	NR	14
ICU LOS					
Pronovost et al,[2] 1999	6 (7)	3.8 (4)	<.05	<.05	37
Kuo et al,[10] 2000	11.8 (13.1)	10.1 (11.0)	<.001	NR	14
Multz et al,[11] 1998 (retrospective)	9.3 (9.3)‡	6.1 (6.1)‡	<.05	NR	34
Multz et al,[11] 1998 (prospective)	12.6 (12.6)‡	6.2 (6.2)‡	<.01	NR	51
Reynolds et al,[12] 1988	8 (10)	10 (11)	NS	NR	−25§
Carson et al,[28] 1996	4.4 (7.1)	4.9 (6.3)	.57	NR	−11§
Ghorra et al,[29] 1999	5.8 (5.8)	5.5 (5.1)	.73	NR	5
Li et al,[30] 1984	4 (3.9)	3.9 (4.9)	.05	NR	3
Manthous et al,[32] 1997	5 (5)‡	3.9 (3.9)‡	<.05	NR	22
Marini et al,[33] 1995¶	9 (9)	4 (4)	<.05	NR	56
Pollack et al,[34] 1988	2 (2)	2 (2)	NS	NR	0
Tai et al,[36] 1998	3 (3)‡	2 (2)‡	.01	NR	33
DiCosmo,[38] 1999	4.1 (4.1)‡	3.6 (3.6)‡	NR	NR	12
Rosenfeld et al,[41] 2000	2.7 (2.7)‡ O/E 0.96	2 (2)‡ O/E 0.86	<.01	<.01	26
Diringer and Edwards,[42] 2001	4.5 (6.2)	7.8 (12.5)	<.05	NR	−73§
Goh et al,[43] 2001	6.8 (10.3)	4.0 (5.6)	<.001	NR	41
Blunt and Burchett,[44] 2000	2.0 (95% CI, 0.8-4.2)	1.9 (95% CI, 0.8-3.5)	NS	NR	5
Hanson et al,[46] 1999	2.8 (2.8)‡	2 (2)‡	<.05	NR	29

*Results are presented as means (SDs) except where noted. ICU indicates intensive care unit; NR, not reported; NS, not significant; and O/E, observed-to-expected mortality ratio based on risk adjustment using the Acute Physiology and Chronic Health Evaluation Score II. Low ICU physician staffing is either no intensivist available or elective consultation; high ICU physician staffing is either mandatory consultation or closed ICU.
†Results were adjusted for baseline severity of illness. Unadjusted and adjusted *P* values shown as reported by the authors.
‡The SD was not provided in the original study and was assumed to be equal to the mean LOS.
§Relative risk increase.
‖Medians reported instead of means. Range is shown in parentheses.
¶Studies have more than one observation period after intervention. Information from the observation period closest to the intervention is included. Data shown are for survivors only.

Figure 4. Unadjusted Hospital and Intensive Care Unit (ICU) Length of Stay (LOS) With Low- and High-Intensity ICU Physician Staffing



Data from studies are plotted with the high-intensity mean LOS as a y-coordinate and the low-intensity mean LOS as an x-coordinate with the 95% confidence intervals (error bars) calculated by the authors of the systemic review. A discrepancy exists between the plotting of the error bars for study 10 in panel B (error bar crosses the line of equivalency) and $P<.001$ (as reported by Carson et al). The diagonal line represents the line of equivalency. Data points below the line of equivalency suggest shorter LOS in the high-intensity group, and those above the line suggest shorter LOS in the low-intensity group. Numbers refer to references (r indicates retrospective; p, prospective). Asterisks indicate SD, assumed to be equal to the mean LOS.

staffing that improved outcome. We found previously that daily rounds by an ICU physician were associated with improved outcomes in patients who underwent abdominal aortic surgery. Yet how daily rounds translate into improved outcomes remains unclear.[2] For example, were the improved outcomes due to specific critical care training and expertise or to increased availability, perhaps with reduced response time, of a team of physicians whose sole responsibility was to provide care in the ICU? Some of the improvements may be possible through alternative staffing models, such as telemedicine.[41] Finally, other ICU characteristics, such as nurse-to-patient ratios, also affect patient outcomes.[65] Determining how to best organize ICU staffing from a multidisciplinary standpoint to optimize patient outcomes is a high research priority. Meanwhile, our findings provide evidence to support the recommendations by the Leapfrog Group[66,67] and Society of Critical Medicine for ICU physician staffing.[68] We believe this systematic review summarizes and clarifies the available literature, helps guide public policy, and provides a basis for future research.

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Author Contributions: *Study concept and design:* Pronovost, Angus.
Acquisition of data: Pronovost, Angus, Dremsizov, Young.
Analysis and interpretation of data: Angus, Dorman, Robinson, Dremsizov.
Drafting of the manuscript: Pronovost, Angus, Young.
Critical revision of the manuscript for important intellectual content: Pronovost, Angus, Dorman, Robinson, Dremsizov.
Statistical expertise: Pronovost, Angus, Robinson.
Administrative, technical, or material support: Angus, Dremsizov, Young.
Study supervision: Pronovost, Angus, Dorman.
Previous Presentation: This study was presented in part at the 2000 Annual Scientific Assembly of the Society of Critical Care Medicine, Orlando, Fla, February 2000.

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BACK OF THE ENVELOPE

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Potential Reduction in Mortality Rates Using an Intensivist Model To Manage Intensive Care Units

CONTEXT. Because of evidence suggesting that outcomes are better in "intensivist-model" intensive care units (ICUs), the Leapfrog Group's hospital safety standards propose that ICUs be managed by critical care physicians (intensivists) who work exclusively in the ICU.

COUNT. Number of lives saved annually in the United States.

CALCULATION. Lives saved = (number of ICU admissions × in-hospital mortality rate of ICU patients) × reduction in mortality rates associated with the intensivist model.

DATA SOURCE. Reduction in mortality rate associated with intensivist-model ICUs was determined by performing a structured literature review from 1986 to the present using MEDLINE. Other variables were estimated from various data sources.

RESULTS. In the nine studies that met our selection criteria, relative reductions in mortality rates associated with intensivist-model ICUs ranged from 15% to 60%. On the basis of the most conservative estimate of effectiveness (15% reduction), full implementation of intensivist-model ICUs would save approximately 53,850 lives each year in the United States.

CAUTIONS. Given the large number of ICU patients and their high baseline risks, even modest reductions in mortality rates would save many lives. Because of potential constraints related to the workforce and other resources, the feasibility of fully implementing intensivist-model ICUs nationwide is uncertain.

Because growing evidence suggests that outcomes are better in intensive care units (ICUs) managed predominantly by full-time intensivists, the Leapfrog Group's hospital safety initiative[1] calls for hospitals to adopt "intensivist-model" ICUs. For hospitals to meet the Leapfrog standard, ICUs must be managed by physicians who are board-certified (or board-eligible) in critical care medicine. During daytime hours, such physicians must be present to provide clinical care exclusively in the ICU. At other times, they will be able to return pages within 5 minutes and rely on in-hospital "effectors" (physicians or physician extenders) who can reach ICU patients within 5 minutes. Using findings from previous studies, we estimated the number of lives that could be saved by full implementation of intensivist-model ICUs nationwide.

See related Policy Matters on pages 313-316.

Methods

As summarized in **Figure 1**, we calculated the number of lives that could potentially be saved by full implementation of intensivist-model ICUs. We started with the

The abstract of this paper is available at ecp.acponline.org.

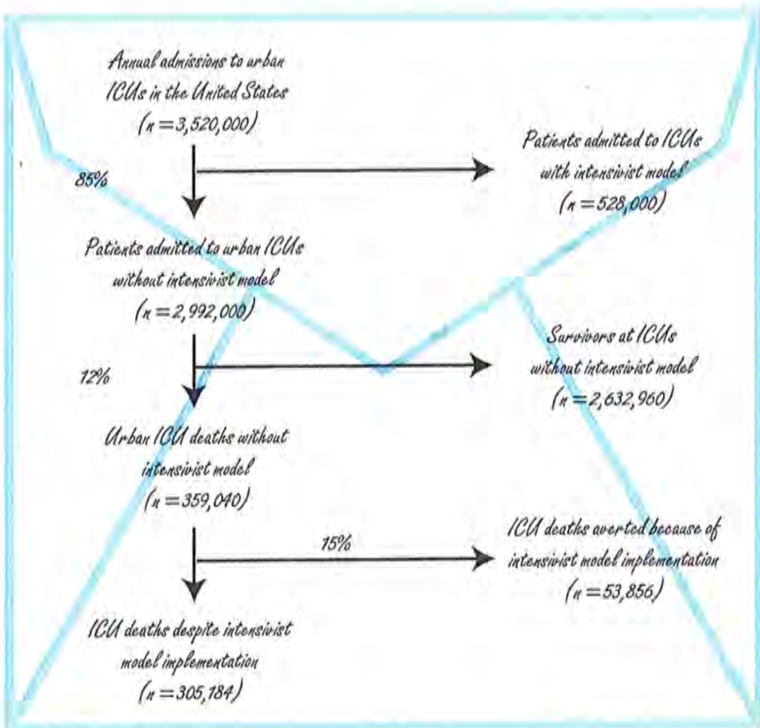

FIGURE 1. Back-of-the-envelope calculation of lives that would be saved each year by full nationwide implementation of intensivist-model staffing in the intensive care unit (ICU).

population of ICU patients potentially affected by the policy and then estimated baseline in-hospital mortality risks and potential reductions in mortality rates associated with implementing intensivist-model ICUs.

Current Number of Admissions to Intensive Care Units

To estimate the number of patients that could potentially benefit from the policy initiative, we determined the number of patients admitted each year to nonintensivist ICUs. We could not directly determine the overall number of patients admitted to ICUs in the United States. According to analysis of the 1999 Medical Provider Analysis and Review file, approximately 2.2 million Medicare patients were admitted to medical or surgical ICUs, excluding coronary care units (Pronovost P. Personal communication). Because Medicare patients represent approximately half of all adult ICU patients (Maryland State data, provided by P. Pronovost), we assumed in our baseline analysis that 4.4 million patients are admitted to ICUs in the United States each year.

To avoid access issues in rural areas, the Leapfrog Group is restricting policy implementation to urban areas. According to analysis of the 1996 American Hospital Association file and census database, 80% of all U.S. hospital beds (and 53% of hospitals) are located in metropolitan statistical areas (MSAs). Assuming that 80% of ICU admissions similarly occur in MSAs, we estimated that 3.52 million patients are admitted each year to ICUs in urban hospitals.

The current proportion of ICUs in the United States with intensivist models is unknown but probably low. In a 1991 national survey, only 22% of hospitals indicated that ICU order writing was restricted to unit staff (i.e., a "closed unit").[2] In a follow-up survey,[3] the same group reported that 17% of ICUs had closed units with respect to order writing. Neither study described the proportion of closed units in which all ICU staff were board-certified (or board-eligible) in critical care medicine or met other Leapfrog criteria. In our baseline analysis, we assumed that 15% of all ICU patients are currently treated in ICUs that meet the Leapfrog standard.

Current Mortality Rates in Intensive Care Units

We estimated average in-hospital mortality rates for ICU patients from two large multicenter studies. Zimmerman and colleagues[4] noted an overall in-hospital mortality rate of 12.4% in 38,000 patients admitted to 161 hospitals between 1993 and 1996. In another study by Shortell and coworkers,[5] in-hospital mortality for 17,000 patients at 42 randomly selected ICUs was 16.6% between 1988 and 1990. In our baseline analysis, we selected the lower (and thus more conservative) of these two estimates: 12%.

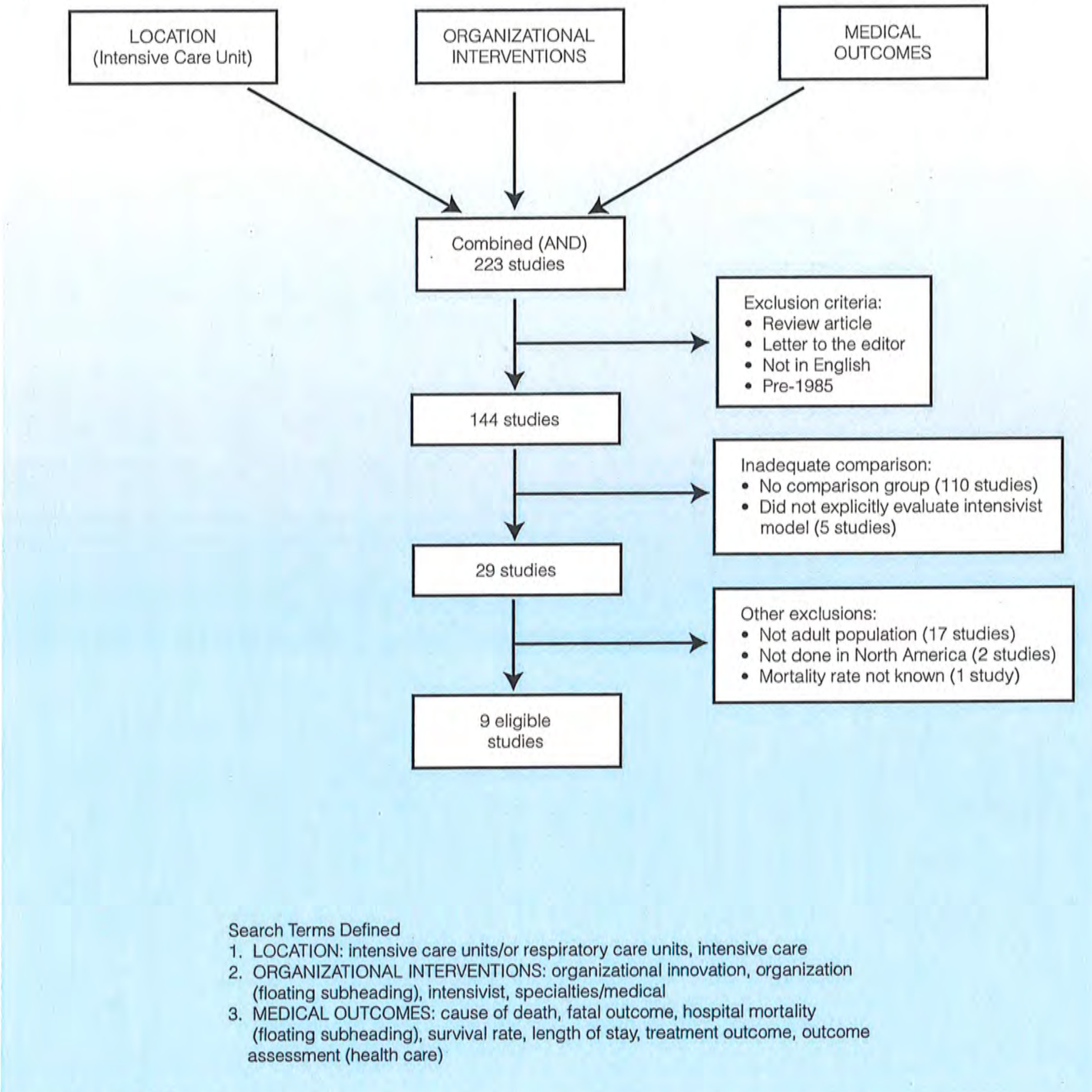

FIGURE 2. MEDLINE search strategy (OVID).

Reductions in Mortality Rates with the Intensivist Model

Many studies have evaluated the effectiveness of similar (although not identical) staffing models in reducing ICU mortality rates. After performing a structured literature review (**Figure 2**), we identified nine studies on which to base our estimates of the effectiveness of implementing intensivist-model staffing.[6–13] Six of these studies were based on pre–post study designs at single sites, all generally large ICUs in teaching hospitals (**Table 1**). Three studies had cross-sectional designs, comparing intensivist model hospitals (or the equivalent) with nonintensivist model hospitals during a single period (**Table 2**).

In all nine studies, intensivist-model staffing was associated with reduced ICU mortality rates. In five of the studies, the reductions in mortality rate were statistically significant. Relative reductions in mortality rates associated with intensivist-model staffing ranged from 15% to 60% (relative risk, 0.85 to 0.4). To be conservative in our calculations of lives saved, we selected the esti-

TABLE 1

Pre–Post Studies of the Effectiveness of Intensivist-Model Staffing in the ICU*

SETTING (YEARS)	MANAGEMENT MODEL FOR INTENSIVE CARE UNITS		HOSPITAL MORTALITY RATE†		UNADJUSTED RELATIVE RISK (95% CI)
	PREINTERVENTION (PATIENTS)	POSTINTERVENTION (PATIENTS)	PREINTERVENTION	POSTINTERVENTION	
Detroit Receiving Hospital (1982–1984)[6]	Internists with ICU housestaff (*n* =100)‡	Full-time intensivists with ICU fellows and ICU housestaff (*n* =112)	74%	57%§	0.77 (0.63–0.94)
Surgical ICU, Plains Health Care Medical Center, Saskatchewan (1984–1985)[8]	Attending physician or surgeon with ICU housestaff (*n* =223)	Same, plus co-management by full-time intensivist (*n* =216)	36%	25%§	0.61 (0.44–0.83)
Medical ICU, Long Island Jewish Medical Center (1992–1993)[7]	Admitting attending with ICU housestaff (*n* =152)	Intensivists with ICU housestaff (*n* =154)	45%	36%	0.80 (0.60–1.08)
Bridgeport Hospital, Connecticut (1992–1994)[9]	Private physicians with housestaff (*n* =459)	Same, plus full-time medical director and co-management by intensivist (*n* =471)	34%	25%§	0.72 (0.59–0.89)
University of Chicago Hospital (1993–1994)[10]	Admitting attending with ward housestaff (*n* =124)	Intensivists with ICU housestaff (*n* =121)	29%	25%	0.85 (0.56–1.29)
Rhode Island Hospital (1995–1996)[11]	Co-management by intensivist (*n* =125)	Management by intensivist (*n* =149)	14%	6%‖	0.42 (0.20–0.90)

**ICU = intensive care unit.*

†Unadjusted except for the University of Chicago study.

‡Internists at Detroit Receiving Hospital were nonintensivists who maintained ambulatory care practices while rotating through as attending physicians in the ICU.

§$P < 0.001$.

‖$P < 0.05$.

mate from the study that demonstrated the least effectiveness (15% reduction). However, in sensitivity analyses, we tested the effect of different assumptions about the effectiveness of intensivist-model ICUs.

Results

In our baseline analysis, we estimated that full implementation of intensivist-model staffing would save approximately 53,850 lives each year in the United States. As expected, the number of lives saved varied according to assumptions about the effectiveness of intensivist-model staffing (**Figure 3**). For example, if we used a relative reduction in mortality rate of 35% (a midrange estimate from the nine studies) instead of 15% (the most conservative estimate), 126,000 lives would be saved.

Discussion

Because so many patients in the United States—approximately 500,000—die in ICUs each year, even small reductions in ICU mortality rates would save many lives. If the Leapfrog Group's initiative is successful in fully implementing intensivist-model ICU staffing in metropolitan areas nationwide, we estimate that approximately 53,850 lives could be saved each year.

Of course, our estimates depend heavily on assumptions about the effectiveness of implementing

TABLE 2

Cross-Sectional Studies of the Effectiveness of Intensivist-Model Staffing*

SETTING (YEARS)		INTERVENTION (PATIENTS)		MORTALITY RATE		UNADJUSTED RELATIVE RISK (95% CI)
CONTROL MODEL	INTENSIVIST MODEL	CONTROL MODEL	INTENSIVIST MODEL	CONTROL MODEL	INTENSIVIST MODEL	
Surgical ICU, University of Pennsylvania Medical Center (1994–1995)[12]	Same†	Attending surgeons with ward housestaff (n =100)	Full-time intensivists with ICU housestaff (n =100)	6%	4%	0.67 (0.19–2.20)
5 Maryland ICUs that manage postoperative AAA repairs (1994–1995)[13]	36 Maryland ICUs that manage postoperative AAA repairs (1994–1995)	No daily rounds by intensivists (n =472)	Daily rounds by intensivists (n =2515)	15%	6%‡	0.40 (0.31–0.52)
Winthrop-University Hospital, New York (1993)[7]	Long Island Jewish Medical Center, New York (1993)	Attending physician with ICU housestaff (n =95)	Full-time intensivists with ICU housestaff (n =195)	38%	28%	0.74 (0.52–1.05)

**AAA = abdominal aortic aneurysm; ICU = intensive care unit.*

†Patients in this study were selected for the control or intervention group (within the same ICU) according to the attending surgeon's preference.

‡$P < 0.01$.

intensivist-model staffing. We chose to be conservative in estimating the potential effectiveness of the method because of several limitations in the original studies and questions about how generalizable their results would be to the nation as a whole. First, inferences from the six pre–post studies are limited by secular trend bias (i.e., mortality rates may have decreased at those hospitals for reasons other than implementation of intensivist-model staffing). The hospitals in these studies may have changed other aspects of care not directly related to physician staffing. Although no evidence shows that ICU mortality rates are decreasing, mortality rates for many clinical conditions are improving over time with advances in science and technology.[14, 15] Second, estimates from the three cross-sectional studies probably suffered from imperfect risk adjustment. Thus, the results of these studies may be partially confounded by unmeasured differences in case-mix between control and intensivist-model groups. Third, caution is required when generalizing results of the nine studies, which were all based at large teaching hospitals, to other settings.

Finally, the "intervention" and the explicitness with which it was described varied substantially in the studies we assessed. Some interventions involved simply adding co-management by a single intensivist to a system primarily run by non–ICU-based physicians; others described extensive changes in staff organization, including completely replacing ward-based teams with intensivists and ICU-based housestaff. It is important to note, however, that the Leapfrog Group's ICU standards fall on the latter, "stricter" side of the spectrum and therefore are likely to be more efficacious.

Although the potential benefits are large, it is uncertain whether full implementation of intensivist-model ICU staffing is feasible from a workforce and resource perspective. Workforce issues have not been studied carefully, but it is unlikely that there are currently enough board-certified intensivists to fully staff ICUs at all hospitals.[15] In hospitals with small units, it may not be economically realistic to restrict the activities of intensivists to the ICU. For these reasons, broad implementation of intensivist-model ICU staffing may require regionalizing intensive care and closing many small ICUs.

Many would argue that the lives saved by intensivist-model ICU staffing are not equivalent to those saved by other public health interventions (e.g., seat belt

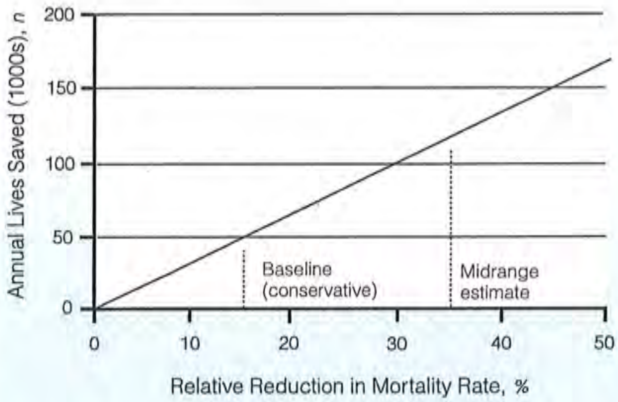

FIGURE 3. Lives saved each year in the United States, according to the effectiveness of intensivist-model staffing in the intensive care unit.

laws). Patients in ICUs often have many comorbid conditions and thus shortened life expectancies compared with the general population. For this reason, future research should consider ways in which improvements in ICU care affect long-term survival and quality of life after hospital discharge.

Take-Home Points

- **Growing evidence suggests that outcomes are better in ICUs managed predominantly by full-time intensivists.**
- **We estimated the potential benefit of nationwide implementation of the Leapfrog Group standards for intensivist-model ICUs.**
- **In our baseline analysis, we estimated that full implementation of intensivist-model staffing would save approximately 53,850 lives each year in the United States.**
- **Because of potential constraints related to the workforce and other resources, the feasibility of fully implementing intensivist-model ICUs nationwide is uncertain.**

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REF 5: MULTZ ET AL

A "Closed" Medical Intensive Care Unit (MICU) Improves Resource Utilization When Compared with an "Open" MICU

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We hypothesized that a "closed" intensive care unit (ICU) was more efficient that an "open" one. ICU admissions were retrospectively analyzed before and after ICU closure at one hospital; prospective analysis in that ICU with an open ICU nearby was done. Illness severity was gauged by the Mortality Prediction Model (MPM_0). Outcomes included mortality, ICU length of stay (LOS), hospital LOS, and mechanical ventilation (MV). There were no differences in age, MPM_0, and use of MV. ICU and hospital LOS were lower when "closed" (ICU LOS: prospective 6.1 versus 12.6 d, $p < 0.0001$; retrospective 6.1 versus 9.3 d, $p < 0.05$; hospital LOS: prospective 19.2 versus 33.2 d, $p < 0.008$; retrospective 22.2 versus 31.2 d, $p < 0.02$). Days on MV were lower when "closed" (prospective 2.3 versus 8.5 d, $p < 0.0005$; retrospective 3.3 versus 6.4 d, $p < 0.05$). Pooled data revealed the following: MV predicted ICU LOS; ICU organization and MPM_0 predicted days on MV; MV and ICU organization predicted hospital LOS; mortality predictors were open ICU (odds ratio [OR] 1.5, $p < 0.04$), MPM_0 (OR 1.16 for MPM_0 increase 0.1, $p < 0.002$), and MV (OR 2.43, $p < 0.0001$). We conclude that patient care is more efficient with a closed ICU, and that mortality is not adversely affected. Multz AS, Chalfin DB, Samson IM, Dantzker DR, Fein AM, Steinberg HN, Niederman MS, Scharf SM. A "closed" medical intensive care unit (MICU) improves resource utilization when compared with an "open" MICU.

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Critical care services account for a large and growing proportion of inpatient services in the United States (1, 2). While intensive care units (ICUs) represent 5 to 10% of all hospital beds, they may consume up to 34% of hospital budgets. This figure extrapolates to over 1% of the gross domestic product (GDP), or over $62 billion (3–5).

In view of the heightened concern regarding the high cost of health care delivery, increasing attention has been devoted to minimizing costs while maintaining quality. Accordingly, efforts have been devoted to the organizational and managerial aspects of care that promote efficient use of scarce resources. Many ICUs in the United States use the "open" model of ICU organization. In this model, patients are admitted, often without triage and are cared for by their primary care physician. In open units, the level of critical care input is variable. Recently, many ICUs have adopted stricter administrative and triage controls, and utilize a "closed" model of organization. In a closed ICU, patients are transferred to the care of an intensivist. Generally, patients are accepted to the unit only after they have been evaluated (6).

Safar and Grenvik first suggested benefits from an intensivist-led intensive care service in 1977 (7). Since then, several retrospective studies have demonstrated an improvement in the outcome of critically ill patients when geographically dedicated intensivists staff, organize, and direct critical care services and the care of all patients (8, 9). In some studies, the availability of qualified intensivists has been linked to lower mortality and costs (10–16).

In the studies cited above, data and outcomes were assessed retrospectively. Recently, however, Carson and coworkers prospectively analyzed the impact of a change in ICU organization from "open" to "closed" within their institution. They demonstrated decreased mortality without additional resource utilization (17). We wished to determine whether the conclusions of Carson and coworkers could be extended to apply between institutions. All of these previous studies only investigated an organizational change within a single institution. We conducted a prospective trial of two units, one "open" and one "closed" in two large hospitals serving similar populations in the same geographic area. To control for possible bias and differences related to institutional care policies unrelated to ICU organization, a retrospective analysis was also performed in one of the hospitals comparing the period before closure with that after closure. We tested the hypotheses that unit clo-

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sure is associated with improved outcome as measured by a decreased mortality, and that unit closure is associated with less resource utilization for similar severity of illness.

METHODS

Sites

Long Island Jewish Medical Center (LIJ) and Winthrop–University Hospital (WUH) are nonprofit teaching affiliates of their respective medical schools. Both serve demographically similar populations and are located within 5 miles of each other. WUH is a 581-bed acute care institution in Nassau County, New York, affiliated with the State University of New York at Stony Brook. The critical care area consists of twenty beds which are jointly shared between the medical ICU and the coronary care unit (CCU). Approximately 50% of the beds are allotted for medical ICU patients. Coronary care patients were not included in this study. The ICU and the CCU have their own medical housestaff team. For the ICU service, a senior resident and two interns are continuously present to provide 24-h in-house coverage for all patients. An attending intensivist and a critical care fellow perform teaching rounds with the housestaff on a daily basis. The MICU, however, functions as an "open" unit, as critical care consultation on admitted patients is optional. Intensivists perform no preadmission evaluation.

LIJ is an 800-bed acute care hospital located in suburban New York City affiliated with the Albert Einstein College of Medicine. The critical care area consists of 30 beds equally allocated between the medical (MICU) and the surgical (SICU) service. The MICU and SICU each have their own housestaff and attending intensivist. Patients in the SICU were not included in this study. The MICU service consists of two senior residents and three medical interns. Twenty-four-hour housestaff coverage is provided.

Before July 1992, the MICU at LIJ was an open unit organized similarly to WUH. In July of 1992, the MICU was closed; that is, the attending intensivist became the physician of record for all MICU patients and a mandatory critical care consultation was required to screen all prospective admissions. Nursing and housestaff coverage remained the same. Mandatory critical care consultation was required in the open unit at LIJ for anyone receiving mechanical ventilation.

There were two study designs carried out for this analysis. First, we performed a prospective cohort analysis where data was collected on a daily basis of all consecutive MICU admissions from May 1, 1993 through August 15, 1993, comparing patients at LIJ (closed unit) with patients at WUH (open unit). Second, we performed retrospective analysis comparing outcomes before and after unit closure at LIJ. The retrospective data were gathered via chart review. Each consecutive MICU admission was evaluated from February 1, 1992 through April 30, 1992 (open ICU) and February 1, 1993 through April 30, 1993 (closed ICU). During each of the periods of closure for both retrospective and prospective cohorts, four different intensivists constituted the attending staff. Thus, a total of eight intensivists were represented during the closed periods. There are many differences between institutions that could influence outcome besides unit management. Thus, the retrospective component, carried out at the same institution served as a validation check for conclusions arrived at in the prospective component. Additionally, no changes in institutional practice patterns (care maps, weaning protocols, etc.) were introduced with unit closure in either component of the study.

During the trial period, LIJ had a ventilator unit that could admit and care for chronic ventilatory patients. This unit was not part of the study. However, it could serve as a place to discharge patients from the LIJ ICU. WUH did not have such a unit during the study. Ventilator time included the time on the ventilator in this unit for these patients.

Data Collection

Data were obtained to assess both clinical outcome and resource utilization. These included patients demographics (age, gender, race), primary and secondary diagnoses, insurance status, source of admission (general medical or surgical floor, emergency room, transfer from another institution), calculation of the Mortality Probability Model score upon admission to the MICU (MPM_0) (18), and ultimate outcome (discharge or in-hospital death). The MPM_0 is a logistic model that uses 11 readily accessible clinical variables available to the clinician on admission to the ICU. Resource utilization data included ICU length of stay (LOS), total hospital LOS, and number of days of mechanical ventilation. Days of mechanical ventilation in the chronic ventilator unit were included in the data. We also recorded the number of invasive procedures (pulmonary artery catheters, central venous lines, arterial lines, and mechanical ventilation) that were recorded for each patient.

Statistical Analysis

Categorical variables were analyzed using chi-square. Continuous variables were analyzed using one-way analysis of variance (ANOVA).

TABLE 1
PATIENT DEMOGRAPHICS*

	LIJ (OR) (*n* = 152)	LIJ (CR) (*n* = 154)	p Value	WUH (OP) (*n* = 95)	LIJ (CP) (*n* = 185)	p Value
Age	61.6 ± 1.5	61.4 ± 1.4	NS	64.2 ± 1.8	62.5 ± 1.4	NS
(range)	(18–96)	(20–95)		(19–97)	(19–90)	
MPM_0	0.31 ± 0.02	0.28 ± 0.02	NS	0.27 ± 0.03	0.26 ± 0.02	NS
(range)	(0.02–0.95)	(0.01–0.93)		(0.01–0.03)	(0.01–0.99)	
Gender	91/61	74/80	$p < 0.04$	49/46	96/89	NS
(M/F)	(60%/40%)	(48%/52%)		(52%/48%)	(52%/48%)	
Caucasian	105 (69%)	118 (71.4%)	NS	82 (86%)	133 (72%)	$p < 0.02$
African-American	30 (20%)	37 (24%)	NS	9 (9.5%)	33 (18%)	NS
Other race†	17 (11%)	7 (4.6%)	NS	4 (4.5%)	19 (10%)	NS
Medicare	85 (56%)	80 (52%)	NS	57 (60%)	106 (58%)	NS
HMO	5 (3%)	9 (6%)	NS	7 (7%)	10 (5%)	NS
Commercial	40 (26%)	44 (29%)	NS	21 (22%)	39 (21%)	NS
Medicaid/self-pay	22 (15%)	21 (13%)	NS	10 (11%)	30 (17%)	NS
% ER admissions	66%	69%	NS	54.3%	77.3%	$p < 0.003$
	(n = 102)	(n = 105)		(n = 52)	(n = 143)	
Mortality	44.7%	36.4%	NS	37.9%	28.1%	NS
	(68/152)	(56/154)		(36/95)	(52/185)	

Definition of abbreviations: OR = open retrospective; CR = closed retrospective; OP = open prospective; CP = closed prospective; LIJ = Long Island Jewish Medical Center; WUH = Winthrop-University Hospital; % ER Admissions = % admissions directly from emergency room.

* All values are expressed as mean ± standard error.

† Hispanic, Asian, or Indian.

TABLE 2

PRIMARY DIAGNOSES

	LIJ (OR) (n = 152)		LIJ (CR) (n = 154)			WUH (OP) (n = 95)		LIJ (CP) (n = 185)		
	No.	%	No.	%	p Value	No.	%	No.	%	p Value
Pulmonary*	54	36	57	37	NS	32	34	65	35	NS
Neurology†	27	18	23	15	NS	12	13	30	16	NS
Gastroenterology‡	23	15	30	19	NS	15	16	27	15	NS
Sepsis	17	11	19	12	NS	15	16	23	12	NS
Cardiovascular§	11	7	9	6	NS	7	7	11	6	NS
Endocrinology‖	5	3	6	4	NS	6	6	10	5	NS
Overdoses	3	2	5	3	NS	6	6	5	3	NS
Other¶	12	8	5	3	NS	2	3	14	8	NS

Definition of abbreviations as in Table 1.

* Pneumonia, respiratory failure, chronic obstructive pulmonary disease exacerbation, asthma, pulmonary embolism, pleural effusion, shortness of breath, hemoptysis, adult respiratory distress syndrome, smoke inhalation, pulmonary hypertension, upper airway obstruction, pneumothorax, pulmonary fibrosis, lung cancer.

† Seizures, cerebrovascular accident, subarachnoid hemorrhage, change in mental status, Guillain-Barré Syndrome, meningitis, sagittal vein thrombosis.

‡ Gastrointestinal bleeding, pancreatitis, hepatitis, liver failure, perforated esophagus, cholangitis, gastric mass.

§ Cardiac arrest, congestive heart failure, myocardial infarction, hypertensive emergency, cardiac tamponade, pericarditis, cardiogenic shock, arrhythmias, aortic aneurysm, congenital heart disease, phlebitis.

‖ Diabetic ketoacidosis, nonketotic hyperosmolar state, hypoglycemia, hypercalcemia, pituitary insufficiency.

¶ Renal (acute renal failure, uremia, hyponatremia, metabolic acidosis, hematuria); Hematology/Oncology (lymphoma, thrombocytopenic thrombotic purpura, sickle cell crisis, bladder carcinoma, angiosarcoma, acute myelogenous leukemia, endometrial carcinoma, epistaxis, antiphospholipid antibody syndrome, hematoma); Ob/Gyn (uterine bleeding, hyperemesis gravidum, pre-eclampsia) trauma, rib fractures, femur fracture, radial fracture, anaphylaxis, antibiotic desensitization, mandibular hypoplasia.

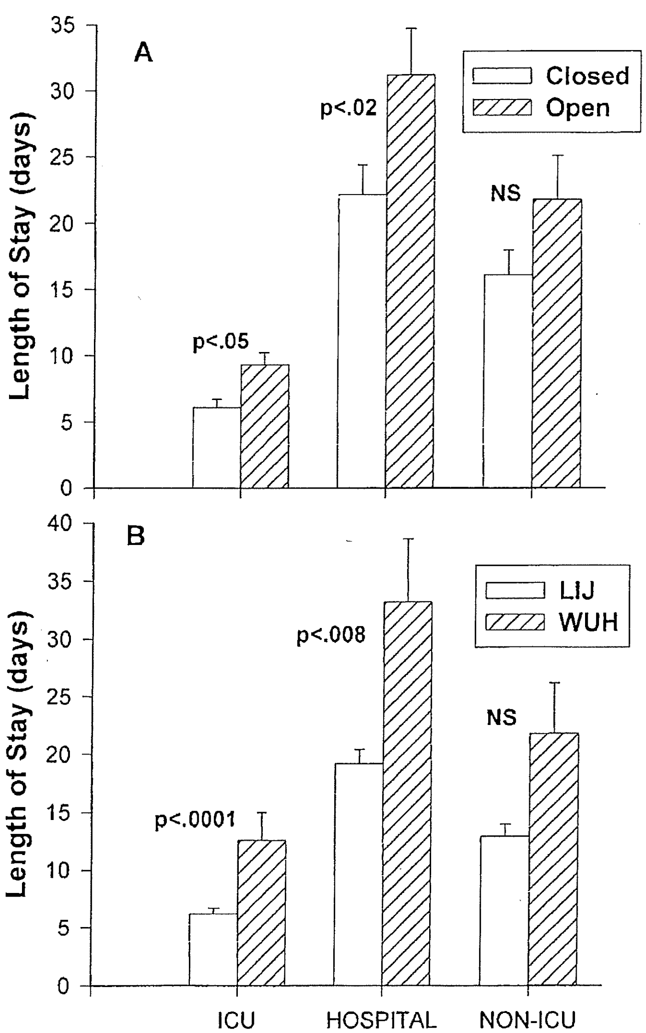

Figure 1. (*A*) These graphs represent the ICU (6.1 ± 0.6 versus 9.3 ± 0.9), hospital (22.2 ± 2.2 versus 31.2 ± 3.5), and non-ICU (16.1 ± 1.9 versus 21.8 ± 3.3) lengths of stay in the retrospective component at Long Island Jewish Medical Center. (*B*) These graphs represent the ICU (6.2 ± 0.5 versus 12.6 ± 2.4), hospital (19.2 ± 1.2 versus 33.2 ± 5.4), and non-ICU (12.9 ± 1.1 versus 21.8 ± 4.4) lengths of stay in the prospective component at Long Island Jewish Medical Center and Winthrop-University Hospital. Values are expressed as mean ± standard error.

If assumptions of normality and equal variance were not met, then ANOVA on ranks was used. The null hypothesis was rejected at the 5% level.

Multivariate regression analyses were also performed on pooled data to assess the predictors of hospital LOS, ICU LOS, and days on mechanical ventilation. A multivariate logistic regression model was developed to assess the influence of the same independent variables upon survival.

All analysis was performed using Statistica for Windows (version 4.5; Statsoft, Tulsa, OK), and Excel (version 5.0; Microsoft Corporation, Redmond, WA).

RESULTS

A total of 280 patients was evaluated in both units in the prospective investigation: 185 were admitted to the closed ICU at LIJ, and 95 were admitted to the open ICU at WUH. A total of 306 patients was evaluated for the retrospective study at LIJ, 152 while the ICU was "open" and 154 while "closed." There were no significant differences in age, mortality, insurance status, and MPM_0 score obtained upon admission between open and closed units in either the retrospective or the prospective analysis (Table 1). A slight male predominance was noted in the retrospective component analysis ($p < 0.04$). Two significant differences, however, were noted in patient origin in the prospective cohort. More patients were admitted from the emergency room in the "closed" (i.e., at LIJ) than in the "open" (i.e., at WUH) ICU ($p < 0.003$) and more Caucasians were admitted in the "open" than the "closed" unit ($p < 0.02$).

There were no significant differences in primary diagnostic categories between open and closed units in either the retrospective or the prospective analysis (Table 2).

For both the prospective and retrospective cohorts, ICU closure was associated with lower hospital and ICU LOS (Fig-

TABLE 3

VENTILATOR DATA*

	LIJ (OR) (*n* = 152)	LIJ (CR) (*n* = 154)	p Value	WUH (OP) (*n* = 95)	LIJ (CP) (*n* = 185)	p Value
% Patients ventilated	46.7% (n = 71)	39.6% (n = 61)	NS	44.2% (n = 42)	35.7% (n = 66)	NS
Ventilator days† (range)	6.4 ± 1.1 (0–87)	3.3 ± 0.6 (0–64)	p < 0.05	8.5 ± 2.3 (0–155)	2.3 ± 0.5 (0–78)	p < 0.0005
Ventilated patient mortality	53.5% (n = 38)	54.1% (n = 33)	NS	42.9% (n = 18)	51.5% (n = 34)	NS

Definition of abbreviations as in Table 1.
* All values are expressed as mean ± standard error.
† Number of days on a ventilator in those patients who were ventilated.

ure 1). There was no difference in the percent of the patients receiving mechanical ventilation, or in their mortality, between closed and open units in either component. However, among patients who received mechanical ventilation, the number of days on mechanical ventilation was lower in the "closed" than the "open" ICU in both cohorts (Table 3).

Table 4 shows the procedure data. In the prospective cohort, the open MICU had a greater number of arterial lines placed ($p < 0.002$). In the retrospective cohort, the closed MICU had a greater number of central lines placed ($p < 0.001$). However, no difference existed between the different units with regard to placing pulmonary artery catheters.

The prospective "closed" cohort at LIJ was also compared with the retrospective "closed" cohort at LIJ. No statistically significant differences were noted in any of the aforementioned outcomes.

Because effects of ICU organization on days of mechanical ventilation, ICU LOS, hospital LOS, and mortality appeared similar in both the retrospective and prospective studies, we pooled the data from all the studies and examined predictors of hospital LOS, ICU LOS, and ventilator days, and predictors of mortality. These included MPM_0, age, gender, mechanical ventilation, the number of days of mechanical ventilation, the use of a pulmonary artery (PA) catheter, arterial and central line placement, and ICU organization type.

Table 5 shows that number of days on a ventilator was the major predictor of hospital and ICU LOS. ICU organization (closed) was a weak, but significant predictor of hospital LOS. Significant predictors of days of mechanical ventilation were ICU organization type and MPM_0 score. However, the regression model accounted for only 7% of the observed variability. The strongest association demonstrated was that between ICU LOS and days of mechanical ventilation, the model accounting for 88% of the observed variability. Table 6 demonstrates that the only significant predictors of mortality were MPM_0 score, mechanical ventilation, and ICU organization type. The use of arterial lines, PA catheters, and central lines, as well as age, gender, and the number of days on a ventilator were not significant predictors of mortality. Overall, however, the model accounted for only 8% of the observed mortality.

The pooled data were then used to compare ICU LOS in patients who received mechanical ventilation and those who did not. 127 patients received mechanical ventilation under the "closed" ICU organization with a mean ICU LOS of 10.2 ± 0.9 d. For those patients who received mechanical ventilation under the "open" ICU organization, the mean ICU LOS was 16.8 ± 2.0 d ($p < 0.00001$). The 212 patients who did not receive mechanical ventilation under the "closed" ICU organization had an ICU LOS of 3.8 ± 0.2 d. 132 patients did not receive mechanical ventilation under the "open" ICU organization and had an ICU LOS of 4.5 ± 0.3 d ($p < 0.002$).

The ventilator unit at LIJ could have altered the ICU LOS at LIJ. Ventilator unit data are summarized in Table 7. To account for possible bias effects, we reanalyzed ICU LOS data including all days spent in the ventilator unit as ICU days. The mean ICU LOS for open retrospective component was 11.0 d and 7.3 d as closed ($p < 0.05$). For the closed prospective component, the mean ICU LOS was 6.73 d and the open prospective component was unchanged from 12.6 d ($p < 0.003$). The same statistical significance was maintained in both components. Further, there was no difference in the utilization of the chronic ventilator unit between closed and open phases of the retrospective analysis. Of the two patients discharged to rehabilitation hospitals, neither was on the ventilator at the time of discharge.

DISCUSSION

This study of ICU organization, resource utilization, and outcome had both a prospective and retrospective component. The diagnostic profile and severity of illness of patients admitted to both types of units in both components were similar. Overall, survival to hospital discharge was not significantly different in either component. However, both components

TABLE 4

PROCEDURE DATA*

	LIJ (OR) (*n* = 152)	LIJ (CR) (*n* = 154)	p Value	WUH (OP) (*n* = 95)	LIJ (CP) (*n* = 185)	p Value
Arterial line	29.9% (n = 44)	34% (n = 51)	NS	33.3% (n = 31)	16.8% (n = 31)	p < 0.002
Central line	15% (n = 22)	30.4% (n = 46)	p < 0.001	14% (n = 13)	13.5% (n = 25)	NS
Pulmonary arterial catheter	9.5% (n = 14)	9.3% (n = 14)	NS	13.8% (n = 13)	9.2% (n = 17)	NS

* All values are expressed as mean ± standard error.

TABLE 5

MULTIVARIATE LINEAR REGRESSION POOLED DATA* (N = 586)

	Hospital LOS			ICU LOS			Ventilator Days		
Independent Variable	Coeff	SE	p Value	Coeff	SE	p Value	Coeff	SE	p Value
ICU organization	5.4	2.6	< 0.04	0.15	0.36	NS	3.75	0.91	< 0.00004
MPM_0	3.02	6.6	NS	0.59	0.91	NS	9.1	2.2	< 0.00006
Gender	1.52	2.5	NS	0.33	0.35	NS	1.61	0.9	NS
Ventilator†	0.30	3.1	NS	0.47	0.41	NS			
Ventilator days‡	1.28	0.13	< 0.00001	0.89	0.02	< 0.00001			
Survival	1.79	2.7	NS	0.40	0.37	NS	0.85	0.96	NS
Age	0.10	0.08	NS	0.004	0.01	NS	0.04	0.03	NS
	R = 0.461			R = 0.939			R = 0.271		

Definition of abbreviation: MPM_0 = Mortality Prediction Model.
* The dependent variable is at the top of each column.
† Being on a mechanical ventilator.
‡ Number of days on mechanical ventilation.

demonstrated that a closed ICU organization was more efficient as measured by a decreased ICU LOS, hospital LOS, and shorter courses of mechanical ventilation. Pooled data from the retrospective and prospective phases demonstrated a slight (odds ratio [or] 1.5) improvement in mortality in the closed ICU organization.

Had there been the introduction of new care policies such as care maps or protocols, along with unit closure, the data could have been confounded. During the retrospective study period, aside from unit closure, no changes in care policy of any sort were introduced at LIJ. Differences in care policies between LIJ and WUH could have influenced data in the prospective component, however, neither unit had at the time of the study introduced care maps, weaning protocols, or other new formal policies. The possibility of confounding variables related to institutional practice patterns between institutions could have confounded the results. These include the greater percentage of patients admitted from the emergency room at LIJ, for instance. However, we believe the influence of unit closure to be robust compared with these factors, because the results of the two components were virtually identical. Because we could find no systematic reason not to assess outcomes predictors between institutions or study components, we felt justified in pooling our data for these purposes.

The prospective component utilized two comparable hospitals, serving similar geographic areas and populations. Aside from unit closure, there were no other alterations in resource allocation relevant to ICU care. The presence of a chronic ventilator unit did not alter the findings. This suggests that unit design has a robust effect on efficiency of care which is demonstrable across institutions as well as within them.

TABLE 6

MULTIVARIATE LOGISTIC REGRESSION POOLED DATA: PREDICTORS OF MORTALITY (R = 0.285)

	Odds Ratio	Confidence Intervals	p Value
MPM_0 (increase in MPM by 0.1)	1.16	1.06, 1.26	< 0.002
Age (increase in age by 20 yr)	1.13	0.89, 1.4	NS
Gender	1.15	0.8, 1.7	NS
Mechanical ventilation	2.43	1.5, 3.9	< 0.001
Ventilator days (increase the number of days by 3)	1.02	0.98, 1.06	NS
Pulmonary arterial catheter	1.19	0.6, 2.34	NS
Central line	1.12	0.64, 1.97	NS
Arterial line	1.57	0.95, 2.59	NS
Closed versus open unit	1.5	1.03, 2.2	< 0.04

The closed ICU in the prospective component admitted a greater percentage of patients from the emergency department. This may reflect a more efficient method of operation with regard to patient screening, differences of "hospital environments," or differences in the socioeconomic status of the patients. There was no demonstrable difference between institutions in LOS or severity of illness. However, Knaus and colleagues demonstrated that patients admitted from the floor to the ICU have a poorer outcome than those admitted from the emergency department, which may have contributed to the differences in ICU and hospital LOS seen in the prospective component despite similar MPM_0 scores (19).

In both components, increased efficiency in closed ICUs was demonstrated by shorter ICU LOS, shorter hospital LOS, and a decreased number of days on mechanical ventilation. In an open ICU system, there may be a delay in both the weaning and extubation process until there has been input from the outside pulmonary or critical care consultant. Recently, Ely and coworkers demonstrated that daily screening of patients receiving mechanical ventilation followed by a trial of spontaneous breathing and subsequent notification of the patient's

TABLE 7

CHRONIC VENTILATOR UNIT DATA

Patient No.	No. of Days in Chronic Ventilator Unit	Outcome
LIJ (OR)		
1	18	Discharged home
2	31	Died
3	126	Discharged home
4	18	Died
5	7	Discharged home
6	1	Died
7	32	Discharged to rehab
8	30	Discharged home
9	18	Discharged home
LIJ (CR)		
1	5	Died
2	6	Discharged home
3	38	Died
4	12	Died
5	112	Discharged home
6	16	Discharged home
7	5	Discharged to rehab
LIJ (CP)		
1	30	Died
2	26	Discharged home
3	40	Discharged home

primary physician resulted in a reduction in the duration of mechanical ventilation and hence a reduction in ICU costs (20). Similarly, in our study the continued presence of an intensivist could have enhanced the likelihood that care decisions were done in a more timely fashion. Table 5 demonstrates that the strongest predictor of hospital and ICU LOS was the number of ventilator days. Therefore, it is likely that the primary effect on LOS of the continuous presence of intensivists is on the duration of mechanical ventilation.

Data regarding procedures showed an inconsistent effect of ICU type on central and arterial lines, and no effect of PA catheters. This differs from other retrospective studies (8, 9), where the presence of intensivists was correlated with an increased use of invasive monitoring. This may reflect changes in the standard of care with time and increased understanding of strengths and limitations of the procedures, especially PA catheters. Further, unlike a recent multicenter study (21), our data failed to demonstrate an association between mortality and PA catheter placement. This probably represents differences in study design and focus.

Patient mortality was not influenced by ICU organization when each cohort was separately examined. However, when all the data were pooled, mortality was most closely correlated with mechanical ventilation, MPM_0 score, and ICU organization. This suggests that a "closed" ICU may be associated with an overall reduction in mortality, although the effect is small. Although these data are similar to those of Carson and coworkers, our observations of a decrease in hospital and ICU LOS differed, as they found no such significance with regard to length of stay in their study (17). A possible explanation for the difference in LOS was the greater severity of illness seen by Carson and coworkers.

In summary, this study demonstrates advantages to a closed ICU organization. Among patients with similar severity of illness, MICU patients may be treated more efficiently in a closed ICU system, with the same or reduced mortality and a lower LOS. Although it may be difficult to accurately estimate true costs when more than one institution is being studied, our results appear to be applicable even when comparing different hospitals.

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Association of changes in the use of board-certified critical care intensivists with mortality outcomes for trauma patients at a well-established level I urban trauma center

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Abstract

Background: An intensivist-directed Intensive Care Unit is a closed-model unit in which a physician formally trained in critical care plays a leadership role in patient management. In the last decade, there has been a move toward closed Intensive Care Units. The purpose of this evaluation was to assess the association of changes in the use of intensivists to a closed-model with mortality outcomes in injured patients seen in a long-established urban Level I Trauma Center.

Methods: This analysis used data from the Scottsdale Healthcare Osborn Medical Center trauma registry from January 1, 2002-December 31, 2008. Mortality prior to hospital discharge was compared in the pre-intensivist (intensivists were not employed and did not provide care), partial intensivist (intensivists were employed and provided care during some Intensive Care Unit shifts) and full-time intensivist (intensivists were employed and provided care in the Intensive Care Unit full time) periods. Multiple logistic regression analysis was used to estimate odds ratios for mortality adjusting for patient characteristics and injury severity for the partial intensivist and full-time intensivist periods compared with the pre-intensivist period.

Results: Of 18,918 patients, 365 (1.9%) died before hospital discharge. After adjustment for demographic factors and injury severity score, for all patients, odds ratios comparing the partial intensivist and full-intensivist periods with the pre-intensivist period were 0.84 (95% confidence interval 0.64-1.11) and 0.99 (95% confidence interval 0.69-1.41). In patients with an injury severity score 16-24, the adjusted OR for death was 0.20 (95% CI 0.07-0.58) comparing the partial-intensivist with the pre-intensivist period and 0.30 (95% CI 0.11-0.88) comparing the full-time intensivist period with the pre-intensivist period. For patients age 65 + years, compared with the pre-intensivist period, odds ratio were 0.51 (95% confidence interval 0.31-0.84) and 0.61 (95% confidence interval 0.32-1.16) for the partial and full-time intensivist periods respectively.

Conclusions: In our setting, a change to a closed Intensive Care Unit model was associated with improved mortality outcomes in patients with less severe injuries and patients age 65+ years.

Introduction

There is convincing evidence that in-hospital mortality outcomes are better for injured patients cared for in Level I Trauma Centers than non-trauma centers [1]. Evidence is limited about the association of other specific staff patterns with outcomes in Level I Trauma Centers [2-4].

Patients in an open Intensive Care Unit (ICU) are managed by independently working physicians who are not generally trained in critical care. An intensivist-directed ICU is a closed-model unit in which a physician formally trained in critical care plays a leadership role in patient management. In the last decade, there has been a move toward closed ICUs. Evidence from a 2002 systematic review and meta-analysis by Provonost

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et al. [5] provided the initial impetus for this move, which was accelerated by the decision by the Leapfrog Group to make ICU staffing with intensivists one of the four focus areas for improvement in hospital safety.

Because many seriously injured patients are admitted to an ICU, the association of patterns of ICU staffing with outcomes for these patients is of interest. In 2006, Nathens et al. reported the results of an analysis of data from a 68-center prospective cohort study of trauma patients, the National Study on the Costs and Outcomes of Trauma (NSCOT), that showed a lower relative risk of in-hospital mortality following severe injury in hospitals with intensivist-model ICUs compared with hospitals with "open" ICUs (RR 0.78; 95% confidence interval 0.58-1.04) [6]. In 2009, Lettieri, Shah and Greenburg reported improved mortality outcomes in an intensivist directed ICU in a combat zone, where about 40% of admissions were for injuries [7].

In 2010, Lee, Rogers and Horst [8] reported the results of an evaluation comparing outcomes for trauma patients managed in a Level II community hospital trauma program before and after introduction of a model for providing ICU care that relied on the closed ICU approach in which dedicated trauma intensivists provided ICU care 24 hours per day, 365 days per year. No significant differences were found in mortality outcomes or total hospital days, but ventilator days, ICU days, and number of medical consults were significantly lower and days to tracheostomy significantly shorter in the period after introduction of the ICU critical care intenstivist model.

The present evaluation took advantage of naturally occurring changes in the use of board-certified critical care intensivists at a long-established, urban Level I Trauma Center to assess the association of changes in the use of intensivisits with mortality outcomes in injured patients.

Methods

Setting

Scottsdale Healthcare Osborn (SHCO) Medical Center is a 334-bed acute care hospital and functions as the only trauma center in the eastern valley of Maricopa County. The Trauma Center was first designated as a Level I center by the state of Arizona in the early 1980's. In October 2008, it was verified by the American College of Surgeons as a Level I Trauma Center. The Trauma Center is located centrally in Scottsdale, Arizona and served a population of about 1-2 million during the period time covered by this evaluation.

Review

The analysis was carried out using deidentified data. It followed local guidelines for ethics committee review of studies based solely on deidentified data, which classify the study as exempt from ethics committee review.

Data source

The source of data for this analysis was the SHCO Trauma Registry. The analysis was based on data about patients included in the registry from January 1, 2002 through December 31, 2008. Although trauma registry data extend back to 1995, the analysis was limited to data collected in 2002 and later due to data quality and completeness. For the variables used in the analysis except Abbreviated Injury Score and injured body part, there were no missing values in 2002 and later.

Information was available on 19,582 patients seen during the period from January 1, 2002-December 31, 2008. Because the SCHO trauma center is not designated as a pediatric trauma center, patients whose age was less than 15 years (N = 203) were excluded from the analysis. Also excluded were patients who were dead on arrival at the trauma center (n = 223); patients with an unknown probability of survival or unknown injury severity scores (N = 125); patients discharged home with a probability of survival of zero (N = 55); and patients not discharged home with injury severity scores of zero and a probability of survival of zero (n = 58). The latter two exclusions were made because the data appeared to be due to errors that could not be corrected without consulting the original medical record. Figure 1 depicts the flow of patients into the analysis.

Use of board-certified critical care intensivists

Prior to October 2005, board-certified critical care intensivists were not employed at SHCO to take care of trauma patients. Board certified critical care intensivists were employed to care for SHCO trauma patients on a limited basis starting in October 2005. Their involvement in the care of trauma patients in the intensive care unit was increased in April 2006. Starting in January 2008, trauma and medical intensivists who were all board-certified provided collaborative care to trauma patients in the intensive care unit full time. This analysis was done comparing mortality outcomes between the three periods defined as follows: a pre-intensivist period (January 1, 2002-September 1, 2005); a partial intensivist period (October 1, 2005-December 31, 2007); and a full-time intensivist period (January 1, 2008-December 31, 2008).

Outcome

The outcome examined in this analysis was death before discharge from SHCO among trauma patients who were alive when first seen in the trauma center.

Analysis

The characteristics of patients and their injuries were summarized by period using counts and percents and, for continuously distributed variables, using means. Associations between period and patient and injury characteristics were tested for statistical significance

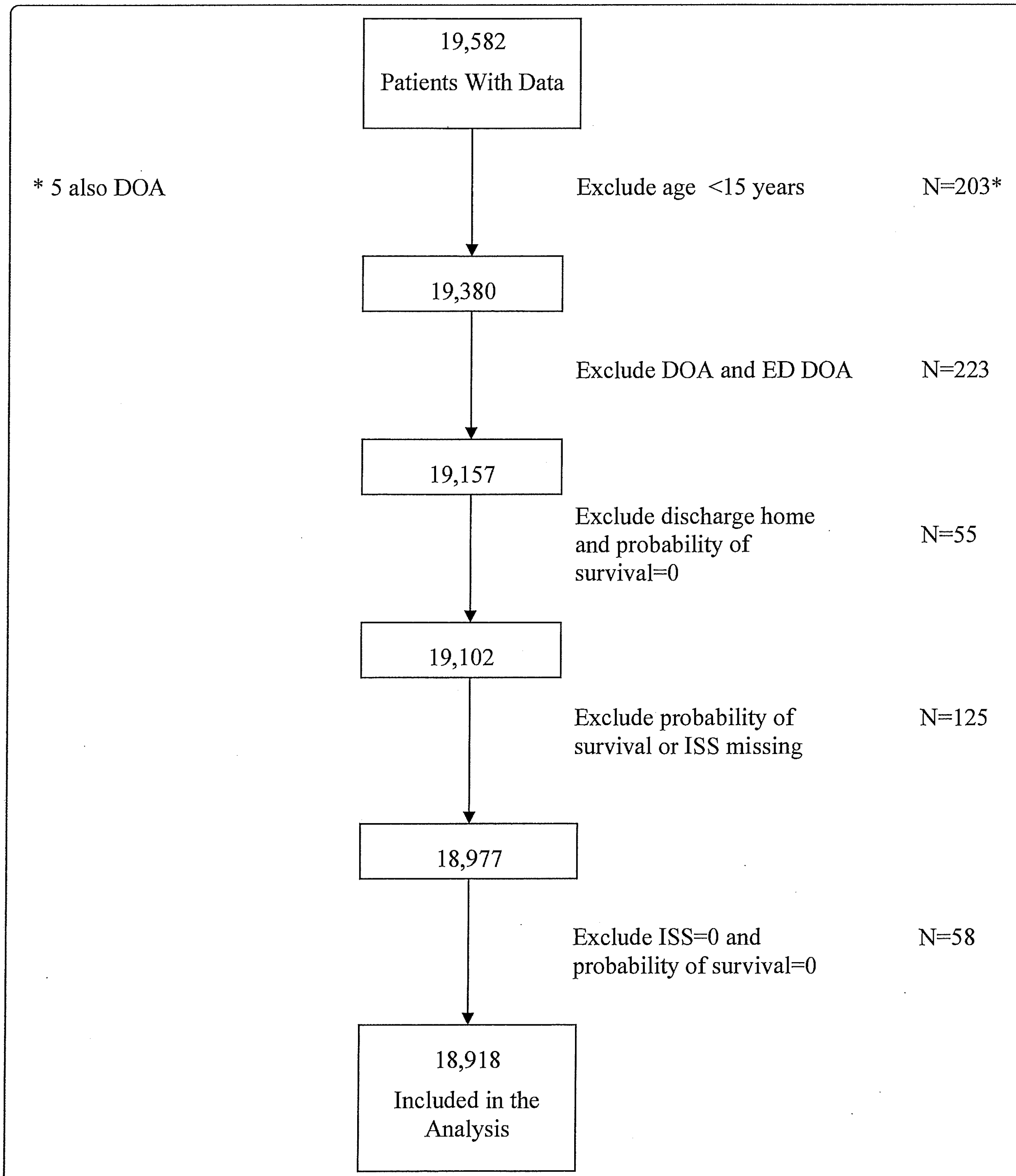

Figure 1 Flow of patient records into analysis.

using the chi-square statistic for categorical variables and analysis of variance for continuous variables.

The first step in the analysis was calculation of crude (unadjusted) odds ratios (OR) and 95% confidence intervals (CI) for the association of patient and injury characteristics and period with mortality. Multiple logistic regression analysis was used to estimate the OR and 95% CI for the association of period with death adjusting simultaneously for age and other patient and injury characteristics.

The association between period and mortality was assessed separately in patients with high injury severity scores [9] defined in three subgroups: 16-25, 25-34, and 35-75. The cut-points for this analysis were chosen to be consistent with a sub-group analysis of trauma outcomes data published in 2009 by McKenney et al. [4]. For injury severity scores less than 16, the number of deaths was small overall (N = 32) and for each period; thus, analysis by period was not done in the subgroup of patients with injury severity scores less than 16. For the other three injury severity score subgroups, crude mortality rates were calculated and the statistical significance of the association of death rate with period was tested using the chi-square statistic. Multiple logistic regression was used to estimate ORs and 95% CIs for death by period within each of three subgroups of injury severity scores adjusting only for age and sex. Inclusion of other variables shown in Table 1 in these subgroup analyses did not change the OR estimate by more than 10%.

The association between period and mortality was also assessed separately in patients age 65+ years adjusting for sex and injury severity score. Inclusion of other variables shown in Table 1 in this analysis did not change the OR estimate in this subgroup by more than 10%.

Model fit was assessed based on the Hosmer Lemeshow test [10].

A P value less than 0.05 (2 tailed) was considered significant. All statistical analyses were conducted using SAS software version 9.1 (SAS Institute Inc., Cary, NC).

Results

Of the 18,918 patients remaining after exclusions, 365 patients (1.9%) died before hospital discharge. Table 1 shows the characteristics of these patients and their injuries by period. There were statistically significant associations between all of the patient and injury characteristics and period (all P's < .05). Of particular note are the lower mean age of patients in the pre-intensivist (37.2 years) compared with the full-time intensivist period (42.6 years) and the higher percentage of patients whose injured body part was categorized as "external," a category that includes lacerations, contusions, abrasions, and burns.

A high proportion of patients had missing Abbreviated Injury Scale (AIS) scores. The percentage of patients with missing AIS scores varied by period. In the pre-intensivist period, data on AIS score were missing for 17.9% of patients. The large amount of missing data on AIS score made it impossible to use the AIS score as either an adjustment or stratification variable in the analysis.

Table 2 ORs and 95% CIs for death adjusting for age and all of the variables in the table. After adjusting for

Table 1 Description of the characteristics of patients and their injuries for the pre-intensivist, partial intensivist, and full-time intensivist periods

Characteristic	Pre-intensivist Period N = 11,399		Partial Intensivist Period N = 5,540		Full-time Intenstivist Period N = 1,979		P-Value*
Age, mean, (SD)	37.2	(17.8)	39.7	(18.8)	42.6	(19.6)	< .001
Died, N, (%)	191	(1.7)	122	(2.2)	52	(2.6)	.004
Male, N, (%)	7,496	(65.8)	3,856	(69.6)	1,403	(70.9)	< .001
Race/Ethnicity, N, (%)							< .001
Hispanic	2,191	(19.2)	1,041	(18.8)	285	(14.4)	
African American	313	(2.8)	161	(2.9)	48	(2.4)	
American Indian	738	(6.5)	360	(6.5)	175	(8.8)	
Asian	97	(0.9)	65	(1.2)	17	(0.9)	
Other/Unknown	146	(1.3)	91	(1.6)	17	(0.9)	
White, non-Hispanic	7,914	(69.4)	3,822	(69.0)	1,437	(72.6)	
Body Part Injured, N, (%)							< .001
Head or neck	4,398	(38.6)	2,140	(38.7)	773	(39.2)	
Face	524	(4.6)	213	(3.9)	84	(4.3)	
Chest	747	(6.6)	572	(10.3)	346	(17.5)	
Abdomen, pelvic contents	538	(4.7)	353	(6.4)	161	(8.2)	
Extremities, pelvic girdle	1,655	(14.5)	1,245	(22.5)	450	(22.8)	
External**	3,533	(31.0)	1,012	(18.3)	160	(8.1)	

Some percentages may not sum to 100.0 because of rounding

* P values are based on the chi-square statistic for categorical variables and analysis of variance for continuous variable comparing the three periods

†14 patients had missing data for injured body part

** lacerations, contusions, abrasions, burns

Table 2 Adjusted odds ratios and 95% confidence intervals (CI) for death for patient and injury characteristics and period

Characteristic	Adjusted for All Variables in the Table Odds Ratio	(95% CI)	P Value
Age	1.03	(1.03-1.04)	< .001
Sex			
Male	1.24	(0.95-1.62)	.12
Female	1.00	(referent)	–
Race/Ethnicity			
Hispanic	0.72	(0.50-1.06)	.10
African American	0.96	(0.36-2.57)	.94
American Indian	1.49	(0.87-2.55)	.14
Asian	1.53	(0.46-5.08)	.48
Other/Unknown	0.79	(0.24-2.65)	.71
White, non-Hispanic	1.00	(referent)	–
Body Part Mainly Injured			
Head or neck	2.12	(0.85-5.29)	
Face	1.00	(referent)	–
Chest	0.78	(0.29-2.07)	
Abdomen, pelvic contents	1.73	(0.63-4.78)	
Extremities, pelvic girdle	0.58	(0.21-1.65)	
External	0.93	(0.32-2.73)	
Injury Severity Score	1.14	(1.13-1.15)	< .001
Period			
Pre-intensivist	1.00	(referent)	–
Partial intensivist	0.84	(0.64-1.11)	.22
Full-time intensivist	0.99	(0.69-1.41.)	.95

age and all of the other variables in the table, the OR for death was 0.84 (95% CI 0.64-1.11) in the partial-intensivist period compared with the pre-intensivist period and 0.99 (95% CI 0.69-1.41) in the full-time intensivist period compared with the pre-intensivist period. The 95% CI for both ORs include 1.0 and neither is statistically significant (both P's ≥ 0.05). The difference in adjusted ORs for death comparing the full-time period(0.99) and the partial intensivist period (0.84) also were not statistically significantly different (P > 0.05).

Table 3 shows death rates and adjusted ORs and 95% CIs in the pre-intensivist, partial intensivist, and full-time intensivist periods in subgroups of patients defined according to injury severity score and in the subgroup of patients age 65+ years. In patients with an injury severity score 16-24, the adjusted OR for death was 0.20 (95% CI 0.07-0.58) comparing the partial-intensivist with the pre-intensivist period and 0.30 (95% CI 0.11-0.88) comparing the full-time intensivist period with the pre-intensivist period. Both adjusted ORs were statistically significantly different from 1.00 (both Ps < 0.05). There was no statistically

significant difference in adjusted ORs for death comparing the full-time intensivist period and the partial intensivist period in other injury severity subgroups (all Ps 0.05). For patients age 65 + years, the OR for death was 0.51 (95% CI 0.31-0.84) comparing the partial with the pre-intensivist period and 0.61 (95% CI 0.32-1.16) comparing the full intensivist with pre-intensivist period. Only the OR comparing the partial intensivist period with the pre-intensivist period was statistically significant (P < 0.05).

Discussion

This study found no association of changes in the employment of board-certified critical care intensivists to provide care to trauma patients in the intensive care unit with an increase or decrease in patient mortality overall. After adjustment, mortality in the subgroup of patients with injury severity scores of 16-24, the least severely injured patients, was statistically significantly lower comparing the partial-intensivist and the full-time intensivist periods with the pre-intensivist periods. In the subgroup of patients' age 65+ years, mortality was also significantly lower in the partial intensivist period compared with the pre-intensivist period but mortality was not statistically significantly lower comparing the full-intensivist period with the pre-intensivist period.

In an analysis of data from the National Study on the Costs and Outcomes of Trauma (NSCOT), Nathens et al. reported mortality outcomes for trauma patients managed in hospitals with intensivist staffed ICUs were better than in open ICUs [6]. In the study by Nathens et al., the mortality outcome difference for trauma patients managed in hospitals with closed ICUs was larger for older (age > 55 years) patients. Our study provides support for the contention that institutions that use intensivists for ICU care affect mortality outcomes more in older trauma patients.

Just as in a similar evaluation by Lee, Rogers and Horst [8] there was no decrease in overall mortality after the change to greater use of intensivists in this setting. When the changes in practice were made, the SCHO trauma center was already well-established. Some of the practices that are believed to mediate better outcomes for trauma patients managed in hospitals with intensivist-run ICUs, such as collaborative team care and use of protocols and guidelines [11], may already have been implemented in this setting at the time of the change in practice.

We do not have an explanation for our finding of significantly lower mortality in the partial and full-time intensivist periods in patients in the injury severity category defined by ISS scores of 16-24 (less severe injury). A number of subgroup analyses were done and the finding may be due to chance.

The results of the study should be interpreted recognizing the difficulties that arise when trying to evaluate the effect of changes in workforce on outcomes. The number of deaths among patients cared for at the SHC

Table 3 For subgroups of patients defined by injury severity score and age, number of deaths, death rates and adjusted odds ratios and 95% confidence intervals (CI) for death by period

	Deaths Number	Patients Number	% Died	Adjusted Odds Ratio	(95% CI)	P Value
Injury Severity Score 16-24						
Pre-intensivist period	30	1,000	3.0	1.00*	(referent)	
Partial intensivist period	5	718	0.7	0.20	(0.07-0.58)	.001
Full-time intensivist period	4	313	1.3	0.30	(0.11-0.88)	.03
All periods	39	2031	1.9	——	——	
Injury Severity Score 25-34						
Pre-intensivist period	78	434	18.0	1.00*	(referent)	
Partial intensivist period	55	335	16.4	0.85	(0.58-1.26)	.42
Full-time intensivist period	29	136	21.3	1.13	(0.70-1.86)	.60
All periods	162	905	17.9	——	——	
Injury Severity Score 35-75						
Pre-intensivist period	64	195	32.8	1.00*	(referent)	
Partial intensivist period	52	146	35.6	1.12	(0.71-1.76)	.62
Full-time intensivist period	16	54	29.6	0.87	(0.45-1.68)	.68
All periods	132	395	33.4	——	——	
Age 65+ Years						
Pre-intensivist period	62	1108	5.6	1.00	(referent)	
Partial intensivist period	33	712	4.6	0.51	(0.31-0.84)	.009
Full-time intensivist period	14	308	4.6	0.61	(0.32-1.16)	.13
All periods	109	2128	5.1	——	——	

* Adjusted for age and sex
†Adjusted for sex and injury severity score

trauma center was small overall, and the study had limited power to detect true effects of changes in the use of intensivists with mortality overall. Critical intensivists might be expected to have their greatest impact on the outcomes of patients who were admitted to the ICU. The rules for collecting data in the early period of the study did not permit identification of patients who were admitted to the ICU. An analysis limited to patients admitted to the ICU might have revealed an association with outcome that is different than for all trauma patients. Data from 664 patients were excluded from the analysis. The effect of these exclusions on conclusions is not known and this is a further limitation.

The statistically significant changes over time in mean age and the distribution of patients according to race/ethnicity probably reflect changes in the demographics of the area served by the trauma center. The change in the distribution of injured body part is a result of policy changes in the criteria for receiving care in the trauma center. There was a striking decrease in the number and proportion of patients in the category for the injured body part that has the label "External," a category that includes lacerations, contusions, abrasions, and burns. These patients were increasingly "triaged" to the emergency department over time. This change probably explains the increase in mean ISS over time. The increase in the proportion of patients who were male may also be a result of the decrease in the proportion of patients seen in the trauma center with these kinds of injuries. We have attempted to account for the changes in patient and injury characteristics by doing multivariate analysis, but the possibility that the statistical adjustment did not fully account for changes in patient and injury characteristics cannot be ruled out.

Mortality in patients seen at the SHCO trauma center appeared to be lower in the categories of ISS that were used in the subgroup analysis compared with other recent published data and with published data from the National Trauma Data Bank (NTDB). McKenney et al. reported mortality rates for 2006-2008 of 2.85%, 23.0%, and 42.2% in trauma patients with ISSs of 16-24, 25-34, and 35-75, respectively, cared for at the University of Miami, Ryder Trauma Center at Jackson Memorial Hospital [4]. Published benchmark mortality rates from the NTDB as presented by Shafi et al. are 7%, 29%, and 54% in trauma patients with ISSs of 16- 24, 25-34, and 35-75, respectively [12].

The differences between the mortality rates observed for the SHCO trauma center and other centers and the NTDB benchmark data may reflect exclusions made in this analysis. It is also possible that the low mortality in patients managed at this trauma center in the period covered by the evaluation is, as discussed above, because some of the practices that are believed to mediate better outcomes for trauma patients managed in hospitals with intensivist-run ICUs [11] had been implemented prior to the exclusive use of critical care intensivists.

Mortality is a crude measure of trauma outcome and effects of the availability of changes in the use of intensivists on other important outcomes of care are not ruled out by this evaluation. Lee, Rogers, and Horst [8] observed significantly lower ventilator days, ICU days, and number of medical consults and significantly shorter days to tracheostomy for trauma patients in a pre/post evaluation of introduction of trauma ICU intensivists to a Level II community hospital trauma program. Length of stay was not examined in our evaluation because data were missing for a large number of patients and the missing data problem was not considered amenable to correction. Data about ventilator days and medical consults was not collected uniformly across the periods of the study and also could not be examined.

Continuing to improve the quality of care for trauma patients and other patients with high acuity is a priority in the United States and elsewhere. The closed ICU is one strategy that aims to improve outcomes in such patients. In our setting, the change to this staffing model was associated with better mortality outcomes in a subgroup of less severely injured patients and in patients age 65+ years. Future research should examine the relationship of use of intensivists with length of stay, cost and patient-centered outcomes.

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Authors' contributions
DP and VB participated in the design of the study. DP conducted the analysis of the data. DP, VB, and CH participated in interpretation of the analysis results and in drafting the manuscript. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

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REF 7: HOWELL ET AL

EFFECTS OF A CLOSED INTENSIVE CARE UNIT MODEL ON PATIENT CARE OUTCOMES

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Article

Abstract

PURPOSE: Research has shown that closed Intensive Care Unit (ICU) systems can improve patient outcomes, decrease length of ICU stays, and improve financial implications for institutions. Our hospital transitioned from an open to closed medical ICU system July 1, 2007. Our goal was to examine the association of this change on a range of clinical outcomes.

METHODS: Chart reviews were performed for all patients admitted to the medical ICU in the months of May and June of 2006 and 2007. We compared the number of admissions, length of stay, Acute Physiology And Chronic Health Evaluation (APACHE) II scores, number and locations of central lines, number of arterial lines, need for and length of intubation, need for reintubation, and 30-day mortality. Independent samples t-tests were used to compare continuous outcomes and Chi-square analyses were used for categorical outcomes.

RESULTS:141 patients were admitted during the open period versus 152 in the closed period. When compared to the open model, the patients in the closed model had: more central lines placed (0.5 versus 0.3; $p=0.001$) with a lower rate of femoral line placement, more arterial lines placed (0.3 versus 0.1; $p=0.001$), and less reintubation (0 versus 4; $p=0.017$). Patients admitted in the closed system showed trends toward higher APACHE II scores (13.9 versus 12.4; $p=0.123$), and shortened length of stay (4.2 versus 4.8 days; $p=0.348$). No significant difference in survival was noted between open and closed models (91.2% versus 88.2% respectively; $p=.391$).

CONCLUSION: Transition to a closed ICU system was associated with more central and arterial lines placed and lower rates of re-intubation. Trends toward increasing severity of illness and shortened length of stay were observed.

CLINICAL IMPLICATIONS: Transition from an open to a closed medical ICU model may result in improved monitoring via central and arterial line placement and possibly shortened length of stays.

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REF 8: HANSON ET AL

Effects of an organized critical care service on outcomes and resource utilization: A cohort study

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Objective: To determine whether the presence of an on-site, organized, supervised critical service improves care and decreases resource utilization.

Design: The study compared two patient cohorts admitted to a surgical intensive care unit during the same period of time. The study cohort was cared for by an on-site critical care team supervised by an intensivist. The control cohort was cared for by a team with patient care responsibilities in multiple sites supervised by a general surgeon. The main outcome measures were duration of stay, resource utilization, and complication rate.

Setting: Study patients were general surgical patients in an academic medical center.

Results: Despite having higher Acute Physiology and Chronic Health Evaluation II scores, patients cared for by the critical care service spent less time in the surgical intensive care unit, used fewer resources, had fewer complications and had lower total hospital charges. The difference between the two cohorts was most evident in patients with the worst APACHE II score.

Conclusions: Critical care interventions are expensive and have a narrow safety margin. It is essential to develop structured and validated approaches to study the delivery of this resource. In this study, the critical care service model performed favorably both in terms of quality and cost. (Crit Care Med 1999; 27:270–274)

Key Words: cohort study; intensive care units; outcome assessment; Acute Physiology and Chronic Health Evaluation score; length of stay; quality of health care; organizational innovation; human; teaching hospitals; prospective studies

The market forces currently operating in American medicine have begun what has been called the industrialization (1) of the medical industry, which has significantly altered the provision of health care in this country. These changes reflect the fear that burgeoning costs will eventually become prohibitive, both for individuals and corporations, or siphon funds from other essential areas, such as education and research. As a result, practice patterns are under scrutiny at the institutional and national levels to eliminate inefficiency, lower costs, and improve clinical results. A substantial decrease in the accelerating rate of the growth of medical costs appears to have been realized already. The current analysis was undertaken to compare the cost and quality of two patterns of critical care practice in an academic medical center.

Surgical critical care medicine developed as a logical adjunct to increasingly ambitious surgical procedures in the 1960s. Intensive care has evolved considerably and now requires substantial investments in space, personnel, and equipment. Because of the frequency of pharmacologic and procedural interventions, critically ill patients are particularly susceptible to complications (i.e., from drug interactions, device-related infections, and procedural misadventures) that prolong stays and alter outcomes. While critical care medicine would therefore seem to be particularly susceptible to the current forces of change, several features of the way in which it is delivered in the United States have largely shielded this component of inpatient hospital care from direct scrutiny. Most particularly, critical care is difficult to describe.

American intensive care medicine practice is relatively inchoate due to the lack of an accepted paradigm for the "best practice." Given the requirement for the efficient allocation of hospital-based physicians to increasingly ill in-patients, it is essential to develop structured and validated approaches to delivery of intensive care.

This study was designed to test the hypothesis that patients receive more efficient care and have better outcomes when they are actively managed by a team of physicians directed by an intensivist and dedicated to the provision of critical care at the bedside than when managed by a team directed by a nonintensivist with simultaneous responsibilities in several sites.

MATERIALS AND METHODS

Study Design. After Institutional Review Board approval, a comparison was made between two cohorts of surgical patients from an academic medical center. All patients admitted to the surgical intensive care unit (ICU) between July 1994 and June 1995 were registered in a large, prospectively designed, intensive care database (ICU Base, University of North Carolina, Chapel Hill, NC). Data from all ICU

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patients admitted were collected concurrently by a nurse data analyst. All general surgical patients from this database were divided into two groups managed with differing care models during their ICU stay. A random subset of 100 patients was then selected from each of the two groups.

One group of patients was managed by a critical care service (CCS) directed by an attending anesthesiologist or surgeon who was certified in, or eligible for, critical care certification from the American Board of Anesthesiology or the American Board of Surgery. Care was provided by critical care faculty, fellows, and residents who were assigned exclusively to the CCS, without other patient care responsibilities. Patients with no critical care service (NCCS) were managed by faculty and resident housestaff who simultaneously provided care in outpatient clinics, on general nursing units, and in the operating rooms. NCCS care was directed by general surgeons who were not certified or board eligible in critical care medicine.

Respiratory care consultation was provided to all NCCS patients (as a matter of ICU policy) by an anesthesiologist certified in critical care who directed a team of anesthesia residents assigned to the ICU.

The assignment of a patient to a cohort depended on whether or not the CCS was consulted at the time of the patient's admission to the ICU. CCS consultation was the prerogative of the primary attending surgeon. For the duration of the study, all referring surgeons exclusively used one model or the other (CCS or NCCS).

Two intensivists attended both services and were assigned to both CCS and NCCS for equivalent periods and exclusively to one service at any specific time. All other intensivists attended solely one service or the other.

Physician and nurse care providers were aware that data were being collected on all patients for administrative reasons but were not informed that a study was being performed.

All patients were cared for by the same nursing staff with a nurse-to-patient ratio of 1:2. Both groups had free access to consultants. Patients in both groups remained on the primary surgical service, and the primary service retained the ability to write orders. The same ICU admission and discharge criteria were used for both groups.

Measurements and Comparisons

Demographics. Cohorts were compared for age, gender, reason for ICU admission, ICU admission source, and severity of illness (Acute Physiology and Chronic Health Evaluation [APACHE] II score taken at time of ICU admission).

Intensive Care Unit Resource Utilization. Data representing overall ICU resource use included arterial blood gases obtained per patient during the ICU stay; total number of units of blood products administered during the ICU stay (red blood cells + fresh frozen plasma + platelets); days of mechanical ventilation; equipment-days (defined as the number of transducers/patient/day + the number of infusion pumps/patient/day); consultations requested (the CCS intensivist and NCCS respiratory intensivist were not included in this number); Medicare-adjusted charges; and ICU and hospital length of stay (as determined by the patient's location at midnight on a given ICU/hospital day).

Outcome Measures. The total number of complications requiring treatment (arrhythmias and hypotensive and septic episodes) were quantified and compared. Arrhythmias were defined as a heart rate of <60 beats/min or >145 beats/min, ventricular tachycardia, ventricular fibrillation, or any dysrhythmia with systolic blood pressure of <90 mm Hg requiring therapy. Hypotensive episodes were defined as a systolic blood pressure of <90 mm Hg for a period of >15 mins. Septic episodes were defined as a temperature of >38.3°C (>100.9°F) or <35.6°C (<96.1°F) plus tachycardia (heart rate of >90 beats/min), tachypnea (respiratory rate >22 breaths/min), and evidence of end-organ hypoperfusion. End-organ hypoperfusion was indicated by hypoxemia (Pa_{O_2} <90 torr [<12.0 kPa] while breathing room air), or hypotension (see above) with cardiac index of >4 L/min/m^2 and systemic vascular resistance index of <700 dyne·sec/cm^5·m^2. Mortality rate was also compared.

Data Management. After comparison of the two cohorts, patients were divided into equal subgroups based on the ICU admission APACHE II score. Ninety-six patients (41 CCS, 55 NCCS) had an APACHE II score of ≤12. One hundred four patients (59 CCS, 45 NCCS) had APACHE II scores of >12. The subgroups were compared to determine whether the effect of the practice pattern changed with severity of illness.

Statistical Analysis. Data were assessed for normality of distribution using Kolmogoroff-Smirnov's test with Lilliefors' correction. Significant differences between the cohorts were determined using Student's t-test (parametric data), the Mann-Whitney rank sum test (nonparametric data), and chi-square analysis. All t-tests were two-tailed and a significant difference was defined as $p < .05$. Unless indicated, all groups are reported using mean ± SEM.

RESULTS

As detailed in Table 1, the majority of patients in both groups were admitted directly from the operating room. A significantly greater number of CCS patients were unscheduled admissions (ICU bed not requested preoperatively).

The reasons for admission (surgical procedure or nonsurgical diagnosis) for each group are shown in Table 2. The surgical categorizations in this table are consistent with those used by the surgical residency review committee of the Accreditation Council for Graduate Medical Education.

Demographic data for the two cohorts are summarized in Table 3 and Figures 1 and 2. The groups differed in admission APACHE II scores: more CCS patients had higher APACHE II scores than the NCCS patients. CCS patients stayed in the ICU for a shorter period of time, had lower days of mechanical ventilation, required fewer arterial blood gases, and fewer consultations. CCS patients also had fewer complications, stayed in the hospital

Table 1. Admission source

Admission Category	CCS	NCCS[a]
Scheduled postoperative	65	82
Unscheduled (OR/hospital floor, ED)	35	16

OR, operating room; ED, emergency department.
[a] $p < .05$ (chi square).

Table 2. Surgical procedure

Reason for Admission	CCS	NCCS
Skin and soft tissue surgery	2	0
Alimentary Tract Surgery		
Esophagus	7	25
Stomach	5	13
Small intestine	10	3
Large intestine	26	6
Abdomen Surgery		
General	3	2
Liver	12	9
Biliary	0	7
Pancreas	20	18
Spleen	3	0
Endocrine surgery	3	4
Nonoperative		
GI Bleeding	4	4
Pulmonary embolus	0	1
Seizure	2	0
Acute respiratory failure	1	2
Acute renal failure	1	0
Visceral embolization	1	1
Hemodynamic monitoring/sepsis	3	2

CCS, critical care service; NCCS, no critical care service; GI, gastrointestinal.

Table 3. Demographics

Category	CCS	NCCS	p Value
Age (yr)	61.33 ± 1.5	59.4 ± 1.3	NS
Gender (female/male)	44:56	40:60	—
ICU admission APACHE II score	13.9 ± 0.5	11.8 ± 0.4	<.01
ICU length of stay (days)	2.0 ± 0.3	2.8 ± 0.4	<.05
Complications/ICU stay	0.5 ± 0.1	1.7 ± 0.3	<.01
Equipment-days	6.5 ± 0.9	9.9 ± 0.4	NS
Arterial blood gases (n)	3.0 ± 0.4	6.1 ± 1.0	<.01
Blood products (units)	1.2 ± 0.3	2.0 ± 0.5	NS
Days of ventilation	0.7 ± 0.3	1.2 ± 0.3	<.01
Number of consultations	1.6 ± 0.1	2.8 ± 0.2	<.01
Hospital length of stay (days)	20.3 ± 2.0	23.6 ± 2.3	<.05
Medicare-adjusted charges[a]	34.5 ± 3	47.5 ± 5	<.01
Deaths during hospitalization	4	6	NS

CCS, critical care service; NCCS, no critical care service; APACHE, Acute Phyisology and Chronic Health Evaluation score; ICU, intensive care unit.
[a]Values are in thousands of US dollars.

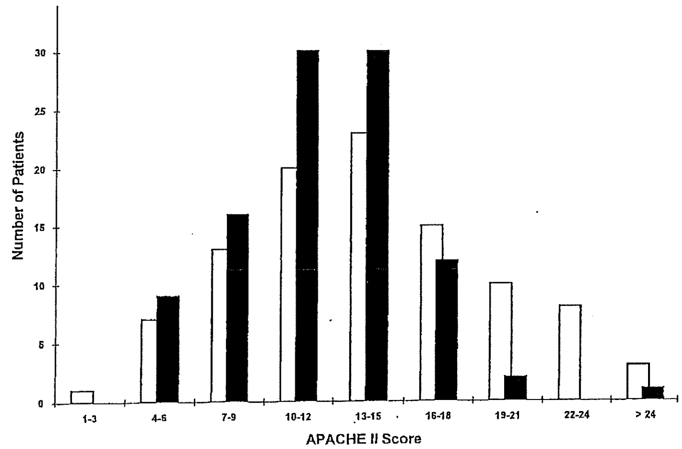

Figure 1. The distribution of the intensive care unit admission Acute Physiology and Chronic Health Evaluation (*APACHE*) II scores for the patients managed by critical care services (*open bars*) and the patients managed by faculty and resident housestaff (*solid bars*) patients.

for a shorter period, and had fewer Medicare-adjusted charges for the total hospital stay. Mortality rate was not significantly different between the two groups. The average ICU length of stay of the CCS patients who died was 9.5 days, whereas that of the NCCS patients who died was 4.8 days.

The APACHE II subgroups are compared in Figure 2. Patients with APACHE II scores of ≤12 differed only in the number of complications and consultations (with fewer of each in the CCS population), and in total (Medicare adjusted) charges. The differences were more pronounced in patients with APACHE II scores of >12. Relative to their NCCS counterparts, the CCS patients were older, and were managed with fewer blood products and equipment days.

DISCUSSION

This study compared two approaches to the management of patients in a surgical ICU. The NCCS model, where patients are managed primarily by nonintensivists with the aid of consultants, is more traditional and more characteristic of the way in which critical care medicine is practiced in the United States (2). The CCS model is an alternative, where an ICU-based service comprehensively manages the intensive care aspects of a patient's stay.

Whereas previous studies (3, 4) have shown decreased mortality rates in ICUs after recruitment of critical care specialists, these studies used historical controls. This study contrasts two approaches to intensive care patient management by physicians using two different, but concurrent, care models. Differences in outcome, cost, or resource use cannot be explained by differences in time, nursing staff, housestaff, ancillary care providers, or site. Because of the organizational structure and referral patterns in this ICU, prospective randomization of patients to the two cohorts was not feasible.

The study suggests that the CCS model provided more efficient care. The stratification of patients into low and high APACHE groups, a strategy that has been used previously (5, 6), demonstrated that the differences between the CCS patients and the NCCS patients were more pronounced with increased severity of illness. The distinction between the two cohorts was most evident in patients with APACHE II scores of >12, where the CCS patients were cared for with less resource use, less cost, fewer consultations, and a

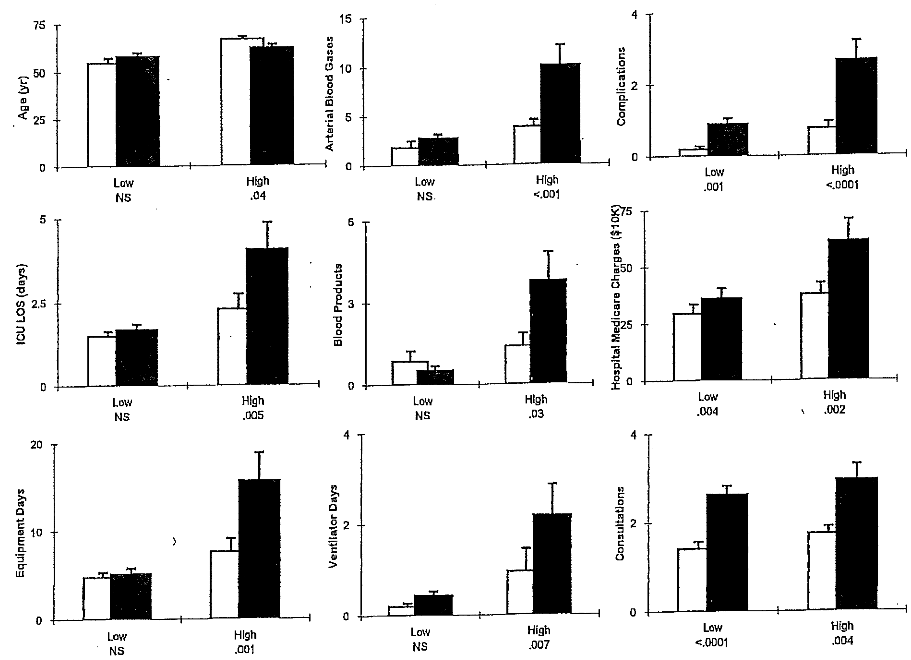

Figure 2. Comparison of the low and high Acute Physiology and Chronic Health Evaluation II score subgroups of the patients managed by critical care services (*open bars*) and the patients managed by faculty and resident housestaff (*solid bars*). ICU LOS, intensive care unit length of stay. Values are given as mean ± SEM.

lower complication rate. We recognize that some of the indicators of efficiency are likely to be associated (e.g., ventilator days and arterial blood gases) but present themselves individually because they represent distinct resource demands.

APACHE II has been validated extensively in the postoperative surgical population as a measure of patient acuity. It has been used to compare patients from within a single unit and among units (7–13).

The comparison detailed here was limited to general surgical patients. The reasons for ICU admission are generally comparable, although there were more biliary and esophageal procedures in the NCCS cohort and more intestinal procedures in the CCS cohort. This fact raises the possibility that some of the differences between the two groups could be explained by a higher rate of thoracotomy (in conjunction with esophagectomy) in the NCCS cohort. To exclude this possibility, all comparisons were repeated after exclusion of patients undergoing esophagectomy. All statistically significant differences remained unchanged. The higher mean APACHE II score of the CCS patients suggests that any outcome bias should favor the NCCS patients. Some differences might have been due to the fact that CCS patients died sooner, either because support was withdrawn more expeditiously or because they were sicker. To exclude this possibility, the average ICU length of stay of the patients dying in the two groups was compared. We found that the CCS deaths occurred later than the NCCS deaths, as indicated in the Results section.

There are several potential explanations for the differences in outcome between the two populations. The CCS, by virtue of the fact that it was present in ICU and, therefore, immediately available at the bedside, may have been more interactive or proactive in the management of emerging patient care issues. NCCS bedside patient care rounds were typically made once per day early in the morning, at which time, strategic medical decisions were made for the day. Patient data were reviewed later in the day but not at the bedside. Unanticipated problems were brought to the attention of the service by the ICU nurse who communicated with an off-site member of the primary team. There was an inherent delay in response, which was therefore reactive. Alternatively, outcome differences might result from team leadership by an intensivist, rather than a nonintensivist general surgeon.

The differences in outcome and resource use between the two groups may be due to the difference in complication rate, physician availability, management style, or some combination thereof. The study also suggests that many of the problems leading to requests for consultation on the NCCS were managed in the CCS model by the on-site team with fewer consultations and equivalent or better outcomes.

The study does not include a financial analysis of the cost implications inherent in caring for a patient with an intensive care service. Physician charges were not analyzed. However, the CCS patients were cared for by one fewer consultant.

The United States Office of Technology Assessment reported a case study of ICUs in 1984 showing that 80% of hospitals in the U.S. had one or more ICUs, and that 15% to 20% of the nation's hospital budget was used in caring for patients in these units. This study (14) concluded that ~1% of the gross national product was used in providing intensive care. Another 1982 national study showed that more than half of the ICUs in the United States were in small hospitals (<200 total beds) and lacked a full-time, salaried medical director (15). A survey conducted a decade later showed substantial variation in the staffing, administration, and organization of ICUs in the United States (16). Of 2,876 ICUs in 1,706 U.S. hospitals, on average, only half were directed by physicians certified in critical care medicine; admission was authorized by ICU attending physicians in ~10%, and the organizational location varied substantially (some ICUs were free-standing and some reported to the Department of Nursing). As the authors of the study (16) concluded, there is a need for "criteria that delineate the characteristics of well managed, high-quality ICUs," both in the interests of cost efficiency and better patient outcomes.

The lack of an accepted paradigm for the delivery of critical care results from several factors. These factors include its youth as a discipline, contention over control of individual patient management, and the absence of a single academic advocate (17, 18). In the future, the provision of critical care services is likely to be affected by diminishing reimbursement, loss of individual physician autonomy in health maintenance organization practices, increasing distinctions between hospital-based and office-based practices, the development of large hospital networks, and an increasing emphasis on demonstrable quality and efficiency in patient care. As provider organizations (insurance companies, health maintenance organizations, hospital networks) come to control a large number of beds in a geographic area, centralization of critically ill patients in well-managed, technologically sophisticated ICUs will become more attractive than less efficient alternatives. Similarly, as institutions increasingly opt for "at risk" contracts, they will seek practice patterns such as the one described in this study, which demonstrably lower costs and improve outcomes.

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REF 9: GAJIC ET AL

Effect of 24-hour mandatory versus on-demand critical care specialist presence on quality of care and family and provider satisfaction in the intensive care unit of a teaching hospital*

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LEARNING OBJECTIVES

On completion of this article, the reader should be able to:

1. Describe the various models of intensive care unit (ICU) care delivery.
2. Explain the effect of a 24-hour mandatory presence of a critical care specialist in the ICU.
3. Use this information in a clinical setting.

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Objective: **The benefit of continuous on-site presence by a staff academic critical care specialist in the intensive care unit of a teaching hospital is not known. We compared the quality of care and patient/family and provider satisfaction before and after changing the staffing model from on-demand to continuous 24-hr critical care specialist presence in the intensive care unit.**

Design: **Two-year prospective cohort study of patient outcomes, processes of care, and family and provider survey of satisfaction, organization, and culture in the intensive care unit.**

Setting: **Intensive care unit of a teaching hospital.**

Patients: **Consecutive critically ill patients, their families, and their caregivers.**

Interventions: **Introduction of night-shift coverage to provide continuous 24-hr on-site, as opposed to on-demand, critical care specialist presence.**

Measurements and Main Results: **Of 2,622 patients included in the study, 1,301 were admitted before and 1,321 after the staffing model change. Baseline characteristics and adjusted intensive care unit and hospital mortality were similar between the two groups. The nonadherence to evidence-based care processes improved from 24% to 16% per patient-day after the staffing change ($p = .002$). The rate of intensive care unit complications decreased from 11% to 7% per patient-day ($p = .023$). When adjusted for predicted hospital length of stay, admission source, and do-not-resuscitate status, hospital length of stay significantly decreased during the second period (adjusted mean difference −1.4, 95% confidence interval −0.3 to −2.5 days, $p = .017$). The new model was considered optimal for patient care by the majority of the providers (78% vs. 38% before the intervention, $p < .001$). Family satisfaction was excellent during both study periods (mean score 5.87 ± 1.7 vs. 5.95 ± 2.0, $p = .777$).**

Conclusions: **The introduction of continuous (24-hr) on-site presence by a staff academic critical care specialist was associated with improved processes of care and staff satisfaction and decreased intensive care unit complication rate and hospital length of stay. (Crit Care Med 2008; 36:36–44)**

Key Words: survey; quality; complications; specialist; outcome; residents; nurses; shift; intensive care

Intensive care units (ICUs) consolidate specialized nursing care and monitoring to support timely introduction of life-sustaining interventions and therapies as well as provide excellence in ethical decision making (1, 2). Several studies have demonstrated improved outcomes of critically ill patients when critical care specialists provide consultative care to primary internists (3) or when critical care specialists are the primary physicians in the ICU (4, 5). Moreover, closing an ICU staff to dedicated ICU teams directed by a critical care specialist improves clinical outcome (6, 7). While high-intensity critical care specialist coverage (mandatory 24-hr availability) has been shown to be superior to a low-intensity critical care specialist coverage, the impact of a mandatory as opposed to "on-demand," on-site critical care specialist presence in an academic center has not been evaluated (8, 9). In the past at our institution, in addition to the daytime and on-demand staff critical care specialists, the medical ICU was continuously (24 hrs) staffed by in-house trainees at the junior resident, senior resident, and ICU fellow level. During the evening and night, a critical care specialist was available via pager and telephone. While the critical care specialist was expected to come to the hospital and physically attend the patient in need, this decision was left to individual physicians and was generally deemed to be variable and inconsistent. With an aim to improve the quality of care, patient safety, and family and provider satisfaction in a tertiary center medical ICU, we implemented an intervention in the critical care specialist staffing model from on-demand to mandatory nighttime coverage. In effect, the new model introduced additional night-shift critical care specialist staffing in week-long blocks in addition to the residents and fellows who were present before the intervention. While such an intervention has the potential to improve quality of care, its effect on patient outcome, process of care, and family and provider satisfaction is not known. We undertook this study to assess the effect of the intervention on these outcomes.

*See also p. 367.

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METHODS

In this prospective study, we compared the quality of care (adherence to best care processes and outcomes) and patient and provider satisfaction before and after the intervention, when the staffing model changed from on-demand presence to mandatory 24-hr staff critical care specialist presence. The Mayo Clinic Institutional Review Board approved the study protocol.

Critically ill patients consecutively admitted to the medical ICU and their care providers, staff critical care specialists, trainees (internal medicine junior residents, senior residents, and ICU fellows), ICU nurses, respiratory therapists, and pharmacists were included in the study. Patients who denied research authorization and those who were admitted for low-risk monitoring (10) were excluded. Providers who did not participate in patient care during both study periods were also excluded.

Characteristics of the medical ICU have been previously described (11). In brief, this is a 24-bed medical ICU with an average daily admission rate of seven and an average midnight census of 16 patients. Before the change in staffing model, two ICU teams, each led by a staff critical care specialist, provided care during the daytime with alternate admission days and nighttime coverage. While one ICU fellow and two internal medicine residents provided continuous in-house nighttime coverage, staff critical care specialists on call were available by pager and were expected to come to the ICU on demand within 15–30 mins after being called. The on-call staff critical care specialist communicated with the on-call fellow via pager and telephone, and decisions about the need to see a specific patient before the next morning were based on the presentation given by the critical care fellow and the severity of illness. Other factors, such as total ICU acuity and activity, could influence the nocturnal in-house presence of the staff critical care specialist. The new staffing model was introduced on January 3, 2006, and consisted of an additional night-shift staff critical care specialist who was to attend to all patient care needs on site between 7 pm and 7 am. This specialist served the same function as the daytime staff critical care specialist, including independent physical examination, review of the medical database, review of the plan of care, supervision of all invasive procedures, and trainee education. The schedule of the night-shift staff critical care specialist was arranged as a block of seven 12-hr night shifts followed by 5 days liberated from on-site work duty. Individual critical care specialists were allowed to shorten the 1-wk block schedule as necessary for personal or professional reasons. Multidisciplinary ICU rounds typically occurred every morning during both periods. Standardized order sets were available for short- and long-term sedation, ventilator management, electrolyte replacement, and sepsis management. No other major practice model interventions were made during the study period.

The following main outcome measures were prospectively compared before and after the staffing change (Fig. 1):

1. Processes of care: adherence to evidence-based practices (12)
2. Acute Physiology and Chronic Health Evaluation (APACHE) III adjusted ICU and hospital mortality, length of ICU and hospital stay (10)
3. ICU complications: ventilator-associated pneumonia (13), deep venous thrombosis (14), pulmonary embolism (14), bleeding, reintubation within 48 hrs of extubation (10), unplanned ICU readmission during the same hospitalization (10, 11)
4. Patient/family satisfaction survey (15)
5. Staff satisfaction survey (16)

Daily prospective bedside screening by the study coordinator or one of the co-investigators determined the adherence to specific processes of care and the development of ICU complications. The following processes of care were compared for 6 months before and after the intervention (Fig. 1): a) sepsis resuscitation (early antibiotics, goal-directed therapy, appropriate use of corticosteroids and activated protein C) (12); b) sedation (daily interruption of continuous sedative infusions) (12); and c) mechanical ventilation (protective mechanical ventilation [17], elevation of the head of the bed [12]), venous thromboembolism, and stress ulcer prophylaxis (12).

Prospective daily data collection included the use of anticoagulation for venous throm-

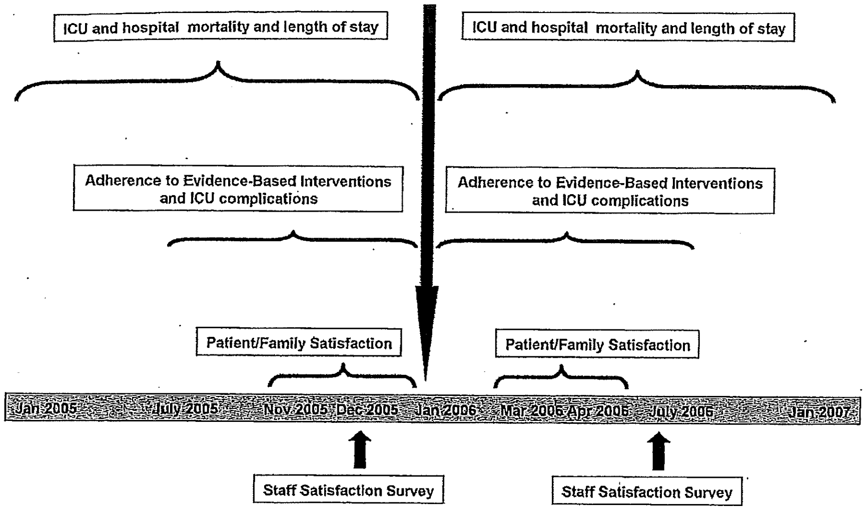

Figure 1. Outline of the study. *ICU,* intensive care unit.

boembolism prophylaxis and type of anticoagulation, the use of sequential compression devices, use and type of stress ulcer disease prophylaxis, daily interruption in continuous sedative infusions, ventilator tidal volumes per predicted body weight, the use of standardized severe sepsis order set, and the contraindications for each intervention. We checked the head-of-bed angle once a day (at random times) from the bedside. The head-of-bed elevation was measured when bed position was not being manipulated for nursing care. Contraindications for anticoagulation included active bleeding, coagulopathy with international normalized ratio >1.5, infusion of activated protein C, thrombocytopenia with platelet count <50 × 109/L, and history of intracranial bleeding during the current hospitalization. Contraindications for use of sequential compression devices included lower extremity trauma, ischemia, or ulcer. Contraindications for daily interruption of sedative inclusions included the use of neuromuscular blocking agents and hemodynamic instability. Contraindications for low tidal volume ventilation included increased intracranial pressure and ventilator weaning. The data needed to determine compliance with the prevention measures were collected daily until the patient was extubated. Adherence to processes of care was calculated as the percentages of patient-days on which eligible patients received evidence-based care (12).

Standard clinical definitions were used to determine the presence of specific critical care syndromes and ICU complications: severe sepsis (18), acute lung injury (19), ventilator-associated pneumonia (13), deep venous thrombosis (14), pulmonary embolism (14), bleeding (20), unplanned reintubation (10, 11), and ICU readmission (10, 11). Bleeding was defined as any bleeding requiring at least one transfusion of packed red blood cells. For gastrointestinal bleeding, we also looked at endoscopy findings. For ventilator-associated pneumonia, we used clinical definitions: new or progressive pulmonary infiltrates plus two of the following: 1) temperature >38°C or <36°C; 2) white blood cell count >12,000/mL or <4000/mL; and 3) purulent endotracheal secretions (13). For patients who had bronchoalveolar lavage, we used the quantitative culture threshold of 10,000 colony-forming units/mL. For venous thromboembolism, we required imaging findings (ultrasound or computed tomography) (14). Severe sepsis and acute lung injury were defined according to international consensus conference criteria (18, 19).

Baseline characteristics and ICU and hospital outcomes were assessed from the prospective data collection by the bedside ICU nurses into the APACHE III database (10) for 12 months before and after the intervention (Fig. 1). The severity of illness and the predicted lengths of ICU and hospital stay were calculated using the APACHE III prognostic model (10, 21).

Patient/family satisfaction surveys were distributed for 2 months before the intervention and were repeated 2 months after the intervention. A previously validated critical care family satisfaction survey (15) was distributed to consecutive consenting ICU families on the second day of ICU stay or the day of ICU discharge (whichever came first). A cumulative score was calculated from five subscale results according to a validated formula (15): (0.858·assurance) + (0.903·information) + (0.781·proximity) + (0.949·support) + (0.554·comfort). A general, two-question patient satisfaction survey was distributed to the patients if they were able to answer the questionnaire by themselves.

The effects of the intervention on staff satisfaction, culture and organization of the ICU, continuity of care, education, and patient safety were measured according to a modified survey previously validated for use in critical care (16). In addition to asking validated questions regarding subjective unit performance and perceived effectiveness, communication and relations within the unit, psychological working conditions and burnout, and job satisfaction and intention to quit, we asked four customized questions regarding overall satisfaction with the staffing model, patient safety, and education and supervision of trainees. The surveys were distributed online via e-mail link during the months of December 2005 (before the intervention) and June 2006 (after the intervention). We performed a paired comparison (each provider being his or her own control) of the responses obtained before and after the change in the staffing model (Fig. 1).

Statistical Analysis. Paired and unpaired Student's t-tests, Wilcoxon's rank-sum test, chi-square test, Fisher's exact test, McNemar test, and Wilcoxon's signed rank test were used as appropriate for univariate comparisons before and after the intervention. A p value $\leq .05$ was considered statistically significant. Incidence rates were compared using the F test (22). To determine whether the critical care specialist staffing model is independently associated with hospital mortality and length of ICU and hospital stay, we created multivariate logistic and linear regression models with APACHE III-predicted mortality or APACHE III-predicted length of stay, age, gender, race, do-not-resuscitate status, admission source, and number of admissions as covariates. SAS statistical software was used for the analysis (SAS version 9, SAS Institute, Cary, NC).

RESULTS

The total number of ICU admissions (including readmissions) increased from 1,995 before to 2,393 after the staffing change. Our medical ICU admitted 6 (range 1–11) patients per 24 hrs before the staffing change vs. median 7 (range 1–14) patients after the staffing change ($p < .001$). Of 3,548 patients admitted over the 2-yr period, 692 (19%) patients were admitted for low-risk monitoring and 234 (7%) denied research authorization. Baseline characteristics were similar during the two study periods except for a higher number of non-Caucasian patients admitted during the second study period (Table 1).

Evidence-Based Processes of Care. Adherence to processes of care and ICU complications were determined for 356 ventilator days in 97 patients before the staffing model intervention and for 963 ventilator days in 191 patients after the staffing model intervention (Tables 2 and 3). Baseline characteristics were similar between the two groups: age (median 65 vs. 67 yrs, $p = .439$), gender (48% vs. 44% female, $p = .486$), APACHE III score (73 vs. 79, $p = .091$), and APACHE III-predicted duration of mechanical ventilation (4.8 vs. 4.7 days, $p = .837$).

The total number of omissions in processes of care decreased from 24% (84 of 356) to 16% (149 of 963) per patient-day ($p < .001$). Adherence to some but not all processes of care improved during the second study period (Table 2). While the rates of appropriate stress ulcer and deep venous thrombosis prophylaxis were excellent even before the staffing model intervention, they improved further during the second study period. In contrast, adherence to elevation of the head of the bed was poor both before and after the intervention. Sedation practice was excellent during both study periods.

ICU Complications and Outcome. The rate of individual ICU complications was low in both study periods (Table 3). Cumulative number of ICU complications decreased from 11% to 7% per day the patient was ventilated in the ICU ($p = .021$). The ICU readmission rate was 9.2% during first period and 7.6% during the second period ($p = .061$). ICU (10.2% vs. 10.4%, $p = .829$) and hospital mortality rate (17% vs. 19%, $p = .328$) did not change during the study period. Median hospital (6.7 vs. 5.9 days, $p = .022$) and ICU (1.7 vs. 1.6 days, $p = 0.025$) lengths of stay decreased after the staffing model change. When adjusted for APACHE III-predicted hospital length of stay, admission source, and do-not-resuscitate status, hospital length of stay significantly decreased during the second period (adjusted mean difference −1.4, 95% confidence interval [CI] −0.3 to −2.5 days, $p = .017$). Adjusted ICU length of stay was not significantly different during the second period (adjusted mean difference −0.2, 95% CI −0.5 to 0.0 days, $p = .080$).

When adjusted for confounding factors, there were no significant differences in ICU and hospital mortality between the two periods. Do-not-resuscitate status on ICU admission (odds ratio 5.7, 95% CI 4.2–7.9) and APACHE III-predicted ICU mortality (odds ratio 1.8, 95% CI 1.7–1.0 for each 10% increase) were the only significant predictors of ICU mortality. Do-not-resuscitate status on ICU admission (odds ratio 4.9, 95% CI 3.9–6.3) and APACHE-predicted hospital mortality (odds ratio 1.6, 95% CI 1.5–1.7 each 10% increase) were the only significant predictors of hospital mortality.

Patient and Family Satisfaction. Eighty-four of 174 (48%) eligible families responded to the first satisfaction survey, and 89 of 203 (44%) eligible families responded to the second satisfaction survey. Mean score was 5.87 ± 1.7 vs. 5.95 ± 2.0 ($p = .777$, with 4 being the best and 22 being the worst). Domain-specific scores were excellent and similar in both study periods (Fig. 2). There was no difference in the mean scores of general patient satisfaction survey between the two periods, 4.81 ± 0.59 vs. 4.82 ± 0.41 ($p = .890$) (on a scale of 0–5, 0 being the worst and 5 being the best).

Staff Satisfaction and Perceptions About the ICU. Paired surveys were answered by 74 of 133 eligible participants: 13 of 15 (87%) attending intensivists, 15 of 21 (71%) physicians in training, 30 of

Table 1. Comparison of baseline characteristics 1 yr before and after the staffing model intervention

	Before (n = 1301)	After (n = 1321)	*p* Value
Age, years, median (IQR)	69 (56–79)	69 (55–79)	.333
Female gender, n (%)	567 (44)	612 (46)	.163
Non-Caucasian race, n (%)	128 (10)	184 (14)	<.001
Postoperative case, n (%)	10 (0.8)	8 (0.6)	.615
Admitted during the night shift (7 pm–7 am), n (%)	554 (43)	598 (45)	.166
Admission source, n (%)			.478
ER	587 (45)	867 (43)	
Direct	142 (11)	140 (11)	
General care hospital area	342 (26)	368 (28)	
ICU	17 (2)	24 (2)	
OR	10 (1)	8 (1)	
Other hospital	203 (15)	214 (15)	
Do-not-resuscitate order at ICU admission, n (%)	309 (24)	307 (23)	.758
APACHE III score, median (IQR)	63 (48–81)	62 (49–78)	.531
Predicted ICU death (%), median (IQR)	7.6 (2.8–19)	7.4 (2.6–18)	.630
Predicted hospital death (%), median (IQR)	16.4 (7.3–35)	15.8 (7.1–33)	.382
Predicted ICU LOS, median (IQR), days	3.9 (2.6–6.0)	3.7 (2.5–6.1)	.462
Predicted hospital LOS, median (IQR), days	14.3 (11–18)	14.4 (11–18)	.725

IQR, interquartile range; ER, emergency room; ICU, intensive care unit; OR, operating room; APACHE, Acute Physiology and Chronic Health Evaluation; LOS, length of stay.

Table 2. Comparison of processes of care for 6 months before and after the staffing model intervention

	Before	After	*p* Value
Ventilator bundle	n = 97 (356 patient-days)	n = 191 (963 patient-days)	
Stress ulcer prophylaxis, n (%)	349 (98)	961 (100)	.002
VTE prophylaxis, n (%)	323 (91)	906 (94)	.038
Daily sedation interruption, n (%), n = 251 days, n = 776 days[a]	250 (99)	761 (98)	.088
HOB ≥30°, n (%), n = 350 days, n = 941 days[a]	209 (60)	572 (61)	.726
Sepsis resuscitation	n = 45	n = 84	
Adherence to standardized order set for severe sepsis, n (%)	32 (71)	69 (82)	.153
Ventilator management of acute lung injury	n = 61 (109 days)	n = 127 (311 days)	
Adherence to low V_T mechanical ventilation, n (%)	79 (72)	251 (81)	.077
Maximum V_T (range) during the first 3 days of ALI (mL/kg)[b]	7.4 (6.0–8.8)	7.0 (6.0–8.7)	.612
Cumulative no. of omissions in processes of care, n (%), n = 356 days, n = 963 days	84 (24)	149 (16)	.002

VTE, venous thromboembolism; HOB, head of bed; V_T, tidal volume; ALI, acute lung injury.
[a]Invasive ventilation; [b]predicted body weight.

55 (55%) critical care nurses, 11 of 35 (31%) respiratory therapists, and 5 of 7 (71%) pharmacists.

Staff satisfaction and perceptions about patients' safety, education, and organization and function of the ICU significantly improved in three of four domains in the cumulative analysis (Fig. 3) with similar trends in subgroups of critical care specialists and allied health staff (Fig. 4). In particular, perceptions about patient safety, supervision, and burnout among the intensivists significantly improved after the intervention (Figs. 3 and 4). The new model was considered optimal for patient care by more providers compared with the old (78% vs. 38%, $p < .001$).

In a *post hoc* analysis we compared the baseline characteristics and outcome of low-risk monitoring patients (excluded from the primary analysis) admitted before and after the staffing change. Except for the patients being older during the second period (median 45 vs. 48 yrs, $p = .026$), baseline characteristics (median APACHE III score 31 vs. 31, $p = .993$) and outcome (median ICU length of stay, 0.83 vs. 0.79 days, $p = .102$; and hospital mortality, 2.7% vs. 2.5%, $p = .876$) were similar before and after the staffing change.

Table 3. Prospective comparison of intensive care unit (ICU) complications 6 months before and after the staffing model intervention

Complication	Before, 356 Days (n = 97)	After, 963 Days (n = 191)	*p* Value
DVT	5 (1.4)	14 (1.5)	.980
PE	3 (0.8)	3 (0.3)	.213
Bleeding	8 (2.2)	8 (0.8)	.047
VAP	9 (2.5)	18 (1.9)	.449
Reintubation	13 (3.6)	21 (2.2)	.147
Cumulative ICU complication rate	38 (11)	64 (7)	.023

DVT, deep venous thrombosis; PE, pulmonary embolism; VAP, ventilator-associated pneumonia. All values are n (%) per patient-day.

DISCUSSION

There is a real need to study ICU coverage and supervision issues rigorously in

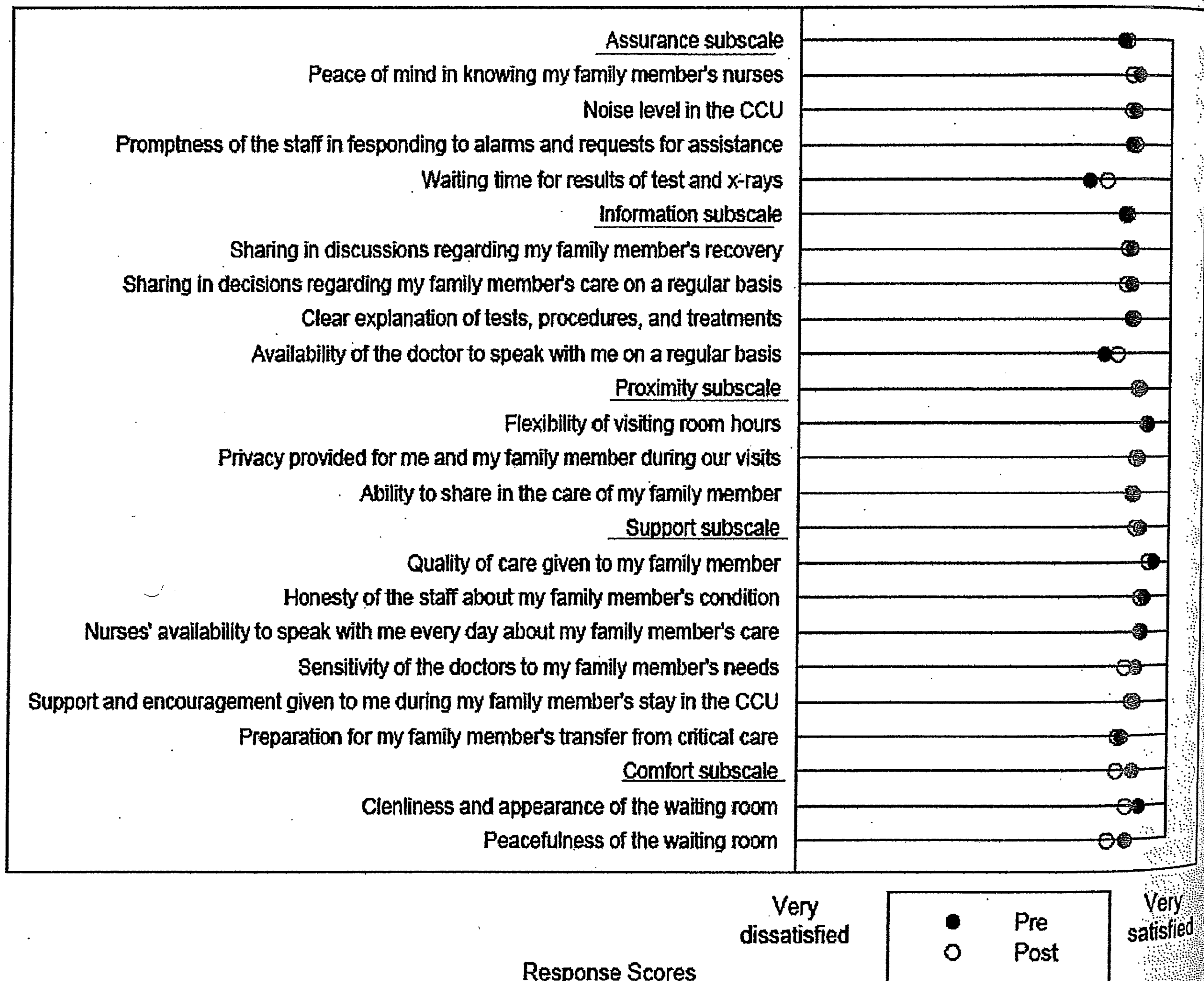

Figure 2. Summary of family satisfaction survey. *CCU*, critical care unit.

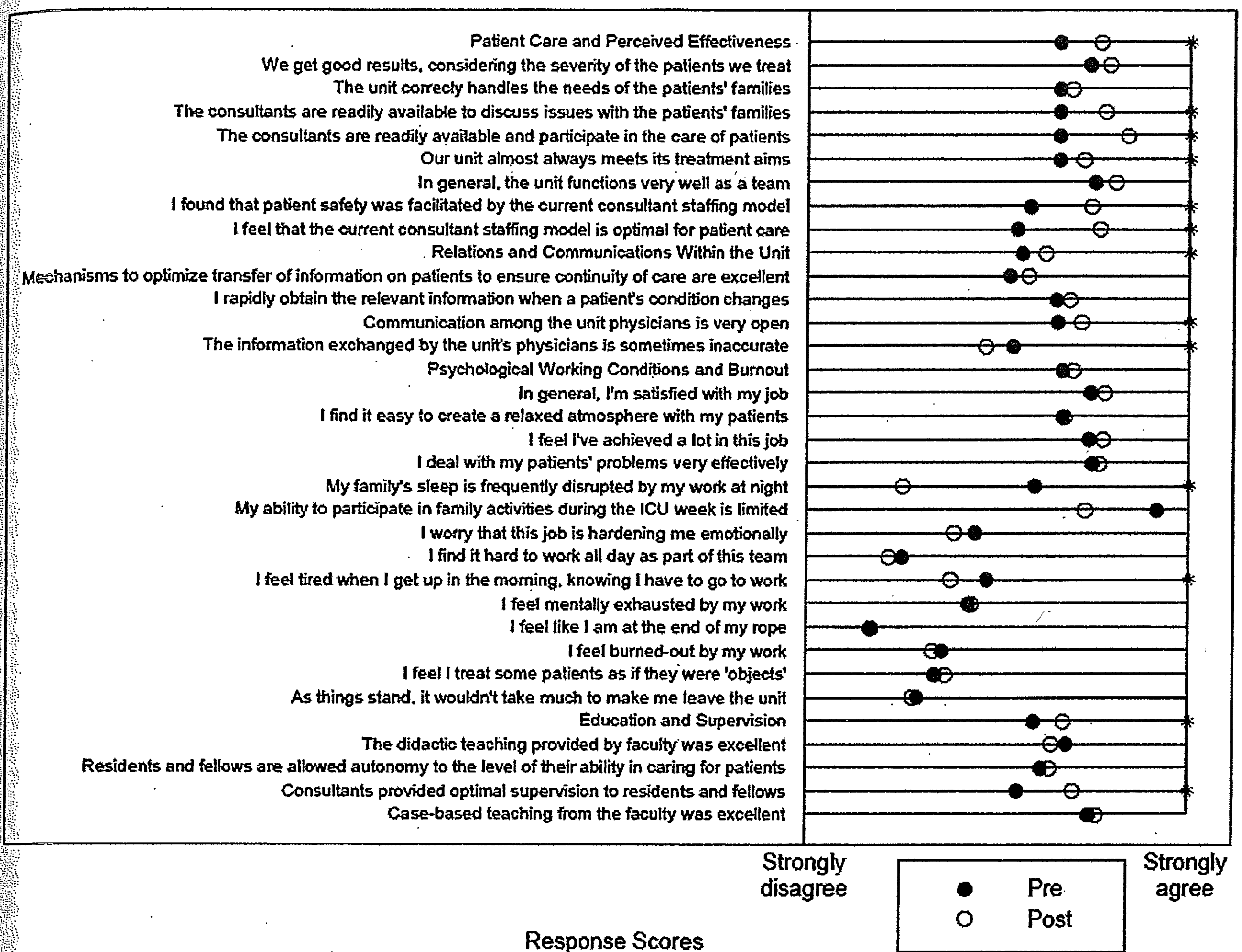

Figure 3. Summary of staff survey. *ICU*, intensive care unit. *Statistically significant comparison.

a prospective fashion, given issues of patient outcomes and the financial/personnel resources that are required to sustain staffing of critical care 24-hr, 7-day systems (23). In the report "Crossing the Quality Chasm," the Institute of Medicine stated that health care in the 21st century should be "safe, effective, patient-centered, timely, efficient and equitable" (24). The mandatory as opposed to on-demand nighttime critical care specialist coverage was introduced to address each of the points outlined in the Institute of Medicine report. The change in staffing model in our institution was feasible and associated with decreased hospital length of stay and improvement in some but not all processes of care. ICU and hospital mortality did not change during the two periods. ICU complications were uncommon and decreased further after the intervention. We demonstrated positive effects on staff satisfaction and perceptions about patients' safety, supervision, and organization and function of our medical ICU. Patient and family satisfaction was excellent during the both study periods.

We and others have noted that variations in ICU practice are often not explained by patient or illness characteristics (25). We speculate that some of the variation in practice and outcome could be due to variability in staffing of academic ICUs at night. Although we did not evaluate the variability in staff critical care specialist presence during the on-demand system, we did determine notable improvements in some ICU processes and outcomes when staff critical care specialists had mandatory on-site presence.

A decrease in adjusted hospital length of stay during the second study period is an interesting finding of our study. The change in adjusted ICU length of stay did not reach statistical significance, possibly due to inadequate sample size. Importantly, the decrease in length of stay was associated not with an increase but with a trend toward decrease in ICU readmission rates (9.2% to 7.6%, $p = .06$), suggesting that the patients were discharged to the floors more safely. Hospital discharge practices and hospital lengths of stay of hospitalized patients in our institution did not change during the study period (mean stay 5.3 days in 2005 vs. 5.2 days in 2006). Among the potential explanations for the observed findings are timely evaluation and documentation by the staff critical care specialist, improvement in some processes of care, and the decrease in ICU complications. Of note, only a cumulative rate of ICU complications demonstrated a statistically significant decrease, likely secondary to a limited sample size and a relatively low rate of individual complications.

While there is little doubt that critically ill patients deserve care by the most experienced providers regardless of the time of the day (2), the association between the time of the day and outcome of

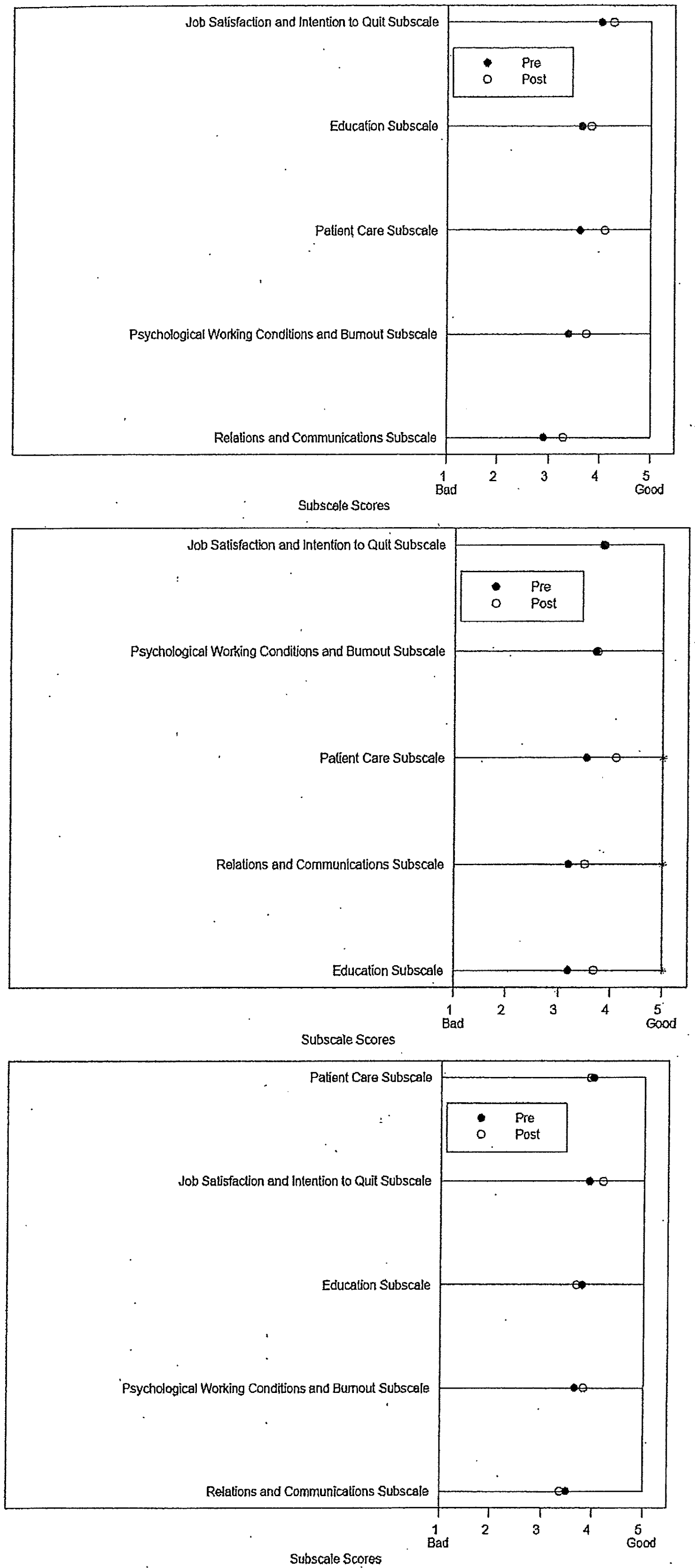

Figure 4. Domain-specific comparisons of the staff surveys before and after the staffing change subgrouped by physician-intensivists (*top*), allied health staff (*middle*), and physicians in training (*bottom*).

ICU patients has not been consistent. Several (26–29) but not all (30, 31) studies reported suboptimal care and adverse outcomes in patients who were treated "off hours." Since the outcome of critically ill patients depends on the continuum of care from the time of admission through discharge from the ICU and beyond, it may not have been easy to pinpoint the relative contribution of potentially suboptimal care provided during off hours. A previous study from Saudi Arabia demonstrated similar outcomes in patients admitted to the ICU during the daytime, nights, and weekends when the ICU was continuously staffed by the intensivist (32).

A projected shortfall of critical care specialists of 22% and 35% for 2020 and 2030 represents a significant challenge to ICU staffing in the United States. This will certainly preclude the adoption of a similar model in all ICUs, and alternative solutions, including telemedicine or selected patient transfer to specialized centers (analogous to level I trauma concept), will have to be considered. Many academic institutions in the United States offer 24-hr, 7-day coverage by dedicated house-staff trainees with critical care specialist backup on demand by either pager or mobile phone (23). However, cogent arguments can be made that the timeliness of care influenced by a staff critical care specialist may be particularly important in some critically ill patients for whom there must be no excuse for waiting "until the morning" (2). In addition, supervision by a staff critical care specialist may reduce medical error and potentially preventable complications (24) and improve ICU team functioning (23). If one believes that intensivist presence or availability improves any outcome, how can it be argued that such presence only need be maintained 7 am to 7 pm?

We observed improvements in some but not all processes of care during the second study period (Table 2). In particular, the adherence to head of the bed elevation remained poor during both study periods. The potential explanations include the provider's bias against the validity of this intervention and the absence of standardized protocol for this predominantly nursing intervention.

The improvements in staff satisfaction and perceptions of care are important findings of our study. The increased pressure to ensure patient safety and resident supervision during recent years has made it very difficult for individual consultants to provide on-demand care during off hours in addition to daytime duties. During the second period, we observed not only improvements in perceptions about patient safety but also satisfaction of the staff critical care specialist, including the ability to participate in family activities during the ICU week and avoid sleep disruption in family members. Concerns were expressed by faculty before the introduction of the model. The schedule of night shifts must be balanced by each individual with commitments to other clinical, academic, and administrative duties. We have not found this prohibitive. The model has been accepted and judged positively. Other practices have evolved in similar ways—for example, hospitalists and emergency room physicians.

We need to point out some limitations of our study design. While a randomized controlled study would allow us to determine the cause-effect relationship between the intervention and the outcome with greater certainty, ethical concerns precluded its use in our study (2). Nevertheless, observational before-and-after study designs clearly preclude stronger inference about the cause and effect of our quality improvement intervention. Regression to the mean and the effect of unmeasured confounders may have contributed to the observed difference after the intervention. While no other quality improvement project was implemented in our ICU during the same time period, the maturation of several quality improvement interventions that were introduced in our ICU over the past several years (standardized order sets for sedation, mechanical ventilation, sepsis resuscitation, and transfusion) may account for some of the observed changes. On the other hand, continuous staff critical care specialist presence should have helped the maturation of these quality improvement interventions and around-the-clock implementation of best practices. There were no significant differences in case mix reflected in the number and severity of ICU patients receiving active intervention (Table 1). Since the APACHE III prediction of the length of stay is based on the worst physiologic observations during the 24-hr period, improved care during the second period could have been masked in adjusted analysis by decreased predicted length of stay of patients who were quickly resuscitated and never developed multiple organ dysfunction. The overall workload in the ICU actually increased predominantly due to the increase in number of patients admitted for low-risk monitoring, suggesting that the availability of additional staff coverage facilitated triage of some patients away from less well-staffed ICUs in our institution.

The data on processes of care and complications were prospectively collected in a predefined subgroup of mechanically ventilated patients for 6 months before (July to December 2005) and 6 months after (January to June 2006) the staffing model change. Increased workload and seasonal variation (a comparison of summer-fall vs. winter-spring) may explain the larger number of patients and patient-days after the staffing model change.

Unfortunately, we do not have exact data regarding the time the intensivists spent during the night in the on-demand period. However, the nighttime supervision of the critical care specialist during the on-demand period (for half of the ICU admissions that occurred 7 pm to 7 am) was perceived as nonuniform and inadequate (as judged by the allied health survey, Fig. 4, *middle*) and unsustainable as a career (as judged by the intensivist survey, Fig. 4, *top*). In the second period, the intensivists were physically present in the ICU during the night for every new admission or a change in patient condition in addition to systematic rounds when the workflow allowed. The staff did feel that the "processing" of nighttime admissions improved the clinical flow and daytime workload, and according to the survey the staff positively judged the change.

The fact that we measured only a limited number of important processes and outcomes is an additional limitation of our study. For example, we did not collect information on the adherence to central catheter bundle and catheter infections. Nor did we collect important data on the accuracy of initial diagnosis and the utilization of diagnostic tests or any economic outcomes other than that inferred from the length of ICU and hospital stay. Finally, relatively poor response to the family satisfaction survey (48% and 44%) may have introduced bias.

The multidimensional approach of our study, however, measuring both the perceptions (patient and staff satisfaction) and the quality of care (processes and adjusted outcomes) allowed us to comprehensively evaluate the impact of two different intensivist staffing models. The outcome measures were based on validated tools recommended by the American Thoracic Society workshop on outcome research in critical care (33) and previously published literature (9, 15, 16).

CONCLUSIONS

In our academic center's ICU, the introduction of an additional night shift to provide mandatory as opposed to on-demand 24-hr staff critical care specialist coverage was feasible and associated with improved processes of care, staff satisfaction, perception about patient safety, organization, and overall ICU function. Future multiple-center studies will determine the generalizability as well as cost-effectiveness of this ICU staffing model.

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Continuing Medical Education Questions

These questions are related to the two preceding articles. Visit the *Critical Care Medicine* Web site (www.ccmjournal.org) for more information on obtaining continuing medical education credit. To obtain credit, you must register on the online site and successfully complete the online quiz. DO NOT use this page to complete the quiz and request scoring and credit.

Questions 1 and 2 refer to the article "Perceptions of a 24-hour visiting policy in the intensive care unit" by Garrouste-Orgeas et al:

1. Which of the following statements is true regarding expanded visiting hours in the intensive care unit (ICU):
   a. All adult ICUs in France have 24-hour visiting hours.
   b. The Joint Commission on Accreditation of Healthcare Organizations requires 24-hour visiting for adult intensive care units.
   c. The major concern about expanded ICU visiting hours relates to the risk of malpractice suits.
   d. In the ICU reported in the study by Garrouste-Orgeas et al., nurses made the final decisions about visiting policies.
   e. In this ICU, friends have the same visitation privileges as family members.

2. This study reports all of the following regarding 24-hour visiting EXCEPT:
   a. The median visit length was 120 minutes per patient per day.
   b. Neither nurses nor physicians perceived open visitation as disrupting patient care.
   c. Physicians reported less family stress.
   d. Nurses were more likely than physicians to perceive disorganization of care.
   e. Physicians reported greater family trust.

Questions 3, 4, and 5 refer to the article "Effect of 24-hour mandatory versus on-demand critical care specialist presence on quality of care and family and provider satisfaction in the intensive care unit of a teaching hospital" by Gajic et al:

3. Which of the following statements is true regarding the study by Gajic et al:
   a. It was performed in a community hospital.
   b. Before the change in staffing model, ICU care was directed by general internists.
   c. It was performed in a 24-bed medical ICU.
   d. Before the staffing change, there was one critical care specialist available to see patients on a consultative basis.
   e. Informed consent was not required.

4. Which of the following statements is true regarding the intervention performed:
   a. The intervention consisted of an additional night-shift critical care attending physician who was to be on site for patient care between 7 pm and 7 am.
   b. The night-shift attending physicians worked every third night.
   c. Critical care fellows were not involved in patient care after the intervention.
   d. Family satisfaction was measured only after intervention.
   e. Fewer patients were admitted after intervention.

5. All of the following statements are true regarding the results of the study by Gajic et al. EXCEPT:
   a. ICU mortality improved after intervention.
   b. Median ICU length of stay decreased after the change in staffing model.
   c. The new model was considered optimal for patient care by more practitioners compared with the old model.
   d. Non-adherence to evidence-based care processes improved from 24% to 16% per patient day after the staffing change.
   e. Perceptions about burnout among the intensivists significantly improved after the intervention.

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Effects of a Medical Intensivist on Patient Care in a Community Teaching Hospital

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• *Objective*: To determine the effect of adding a trained intensivist on patient care and educational outcomes in a community teaching hospital.

• *Material and Methods*: We retrospectively reviewed outcomes for patients admitted to the medical intensive-care unit (MICU) of a 270-bed community teaching hospital between July 1992 and June 1994. Mortality rates and durations of stay were determined for the year before (BD, 1992 through 1993) and the first year after (AD, 1993 through 1994) introduction of a full-time director of critical care. Performance of resident trainees on a standardized critical-care examination was measured for the same periods.

• *Results*: Overall, 459 patients in the BD period were compared with 471 patients in the AD period. The mix of cases and severity of illness (acute physiology and chronic health evaluation or APACHE II scores) on admission were similar for the BD and AD periods. MICU mortality decreased from 20.9% during the BD to 14.9% during the AD period ($P = 0.02$), and in-hospital mortality decreased from 34.0% to 24.6% ($P = 0.002$). Disease-specific mortalities were lower during the AD period for most categories of illness. Detailed analysis of a subgroup of patients (those with pneumonia) demonstrated no differences in distribution of patients by gender, race, or acuity of illness (APACHE II scores). The mortality rate due to pneumonia decreased from 46% during the BD period to 31% during the AD period. This decrease was consistent across categories of APACHE II scores. From BD to AD periods, mean durations of total hospital stay decreased from 22.6 ± 1.4 days to 17.7 ± 1.0 days, and mean MICU stay decreased from 5.0 ± 0.3 days to 3.9 ± 0.3 days ($P<0.05$). Critical-care in-service examination scores for 22 residents increased from 53.8 ± 1.7% to 67.5 ± 2.2% ($P<0.01$), and AD scores were significantly higher than BD scores for residents at similar levels of training.

• *Conclusion*: Addition of a medical intensivist was temporally associated with improved clinical and educational outcomes in our community teaching hospital.

(*Mayo Clin Proc 1997; 72:391-399*)

AD = after director; APACHE II = acute physiology and chronic health evaluation; BD = before director; ICUs = intensive-care units; MICU = medical intensive-care unit

In 1987, the American Board of Internal Medicine began to certify critical-care medicine as a subspecialty of internal medicine.[1] Despite the development of more than 100 training programs in the United States,[2] the role of the medical intensivist in the administration of critical care has remained poorly defined.[3,4] The utility of the full-time, hospital-based intensivist remains particularly nebulous in community hospitals because few studies have examined the effect of adding a medical intensivist on teaching and patient care in this setting.[5,6] Insofar as the goals of the American medical system include providing high quality care at the highest possible efficiency, such data are necessary to justify integration of intensivists in the care of critically ill patients.

For accompanying editorial, see page 483

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In the current study, we examine the effects of an intensivist on medical education and patient outcomes in a community teaching hospital. We then explore the implications of this study for the administration and education of critical care.

METHODS

This study was conducted in patients admitted to an 8-bed medical intensive-care unit (MICU) in a 270-bed community teaching hospital between July 1992 and July 1994. The hospital has several residency training programs, including one in internal medicine, and separate medical, cardiac, surgical, and pediatric intensive-care units (ICUs). No changes in dismissal or admission criteria, nurse:patient ratios, or resident staffing occurred during the study period. Before 1993, the MICU had no full-time director; however, admission and dismissal criteria guided patient disposition, and consultants from various specialties contributed to the care of patients. Critical-care education included a syllabus and ad hoc teaching by hospital pulmonologists.

In July 1993, a medical intensivist, who was certified in internal medicine and who had completed a 2-year critical-care training program, began as full-time MICU director. His primary responsibility was to provide education and guidance for medical resident trainees in the management of critically ill patients. Private physicians admitted their patients and had ultimate authority in requesting consultations, in decision making, and in their patients' dispositions. The MICU director admitted and cared for all state welfare patients (approximately 10% of admissions) and provided formal consultations when requested. Throughout the study period, all patients were cared for 24 hours/day by the medical residents, who had sole authority in writing orders. The intensivist conducted teaching and work rounds each morning, during which all patients were presented by the residents in complete systematic fashion. Most cases were reviewed with house staff for appropriateness of admission (as determined by *preexistent* admission criteria) and for educational purposes. Medical care plans were then formulated by the team. When appropriate, care plans were discussed with the private physicians, and their input was also incorporated. In addition, the director supervised management of patients with acute decompensation and conducted formal didactic sessions with the house staff for 2 to 3 hours/day for those on the MICU rotation. He also conducted approximately 24 1-hour sessions for the entire house staff throughout the year.

The MICU maintains an admission logbook. Patients who were cared for by cardiac or surgical intensive-care personnel ("boarders" in the MICU) were deleted from the list. Names of patients in the MICU during the study period were submitted to the hospital data-processing department, and automated records of outcomes, durations of stay (both total in-hospital and in-MICU), and places of disposition were obtained. No changes occurred in the MICU logging protocol, automated record system, or criteria for day counts during the study period.

Mortality, Disposition, and Acuity of Illness.—Patients admitted to the MICU were compared for mortality (case-fatality) rates between the period July 1992 through June 1993 (BD, before director) and July 1993 through June 1994 (AD, after director). Mortality rate, for the purpose of this study, was defined as the ratio of deaths to the total number of admissions for the specified period and was expressed as a percentage. AD and BD in-hospital and in-MICU all-cause mortality rates were compared by *z* test (based on differences between the sample proportions). In addition, the unadjusted all-cause mortality rates for the year before and after the study period were calculated in order to delineate period trends further. APACHE II (acute physiology and chronic health evaluation) scores were not available for the BD period. Accordingly, a 20% random sample was obtained for the BD period, and their admission APACHE II scores were computed. Admission APACHE II scores were available for 58% of patients in the AD period and were compared with the BD sample by use of the nonpaired Student *t* test.

To ensure that differences in crude death rates were not due to differences in case mix over time, we compared disease-specific mortality rates for the AD and BD periods. APACHE II scores, matched for ICU admitting diagnosis, were not readily available for all subjects. Accordingly, the disease-specific comparisons could not be adjusted for possible differences in severity of illness. To address the possible confounding from variations in disease severity, we obtained the medical records of all subjects with the diagnosis of pneumonia and reviewed them in greater detail. Additional data abstracted from these records included age, race, gender, admission APACHE II scores, duration of mechanical ventilation, ICU days, pre-ICU location, rebound rate, and duration of hospital stay before ICU transfer. Patients with pneumonia were selected for this greater scrutiny because they constituted about 10% of ICU admissions during *both* time periods and because their age composition roughly mirrored the population of ICU admissions for any period.

Duration of Stay.—Total hospital and in-MICU durations of stay (day counts based on occupancy at midnight) were compared for the BD and AD periods by use of the nonpaired Student *t* test.

Education.—A formal critical-care curriculum (available from the first author on written request), consisting of daily lectures to residents on the MICU rotation and of bimonthly

Table 1.—**Comparison of Disease-Specific Case-Fatality Rates for Selected Diseases During the Periods Before and After Establishment of an Intensivist as Director of Critical Care***

	1992-1993 (BD)		1993-1994 (AD)		
Disease	No. of cases	Mortality rate (%)	No. of cases	Mortality rate (%)	Mortality rate ratio (AD/BD)
All causes	459	34.0	471	24.6	0.72
Cardiovascular	40	45.0	53	18.9	0.42
MI, angina	11	54.5	8	12.5	0.23
CHF	15	40.0	9	33.3	0.83
Other	14	42.9	36	16.7	0.39
Respiratory	117	35.9	122	23.0	0.64
Pneumonia	52	46.0	58	31.0	0.67
COPD	18	33.3	22	18.2	0.55
Asthma	10	10.0	8	0	0
Other	37	29.7	34	17.6	0.59
Infectious	57	42.1	44	45.5	1.08
Sepsis, sepsis syndrome, shock (not pneumonia or HIV)	49	34.7	38	39.5	1.14
HIV-related infections (not pneumonia)	8	87.5	6	83.3	0.95
Gastrointestinal	98	27.6	91	19.8	0.72
GI bleeding, ulcer, varices	45	15.6	38	10.5	0.67
Cirrhosis, hepatic coma	19	47.4	20	30.0	0.63
Other	34	32.4	33	24.2	0.75
Central nervous system	38	23.7	39	33.3	1.41
CVA	18	38.9	22	45.5	1.17
Seizures	9	0	11	9.1	...
Other	11	18.2	6	33.3	1.83
Renal	16	31.3	27	25.9	0.83
Endocrine	20	20.0	24	12.5	0.62
Poisonings or overdoses	26	7.7	38	0	0
Others†	47	53.2	33	51.5	0.97

*AD = after director; BD = before director; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; GI = gastrointestinal; HIV = human immunodeficiency virus; MI = myocardial infarction.

†Most cases in this category were patients transferred from the orthopedic service after surgical treatment of fractures or patients with malignant lesions.

lectures to the entire house staff, was initiated in the AD period. In addition, each member of the house staff received a copy of the syllabus[7] used for the critical-care medicine course. A standardized 40-question critical-care examination (available from the first author on written request) was administered to internal medicine residents early in July 1993 (BD) and after 1 year of training in June 1994 (AD). Questions for the in-service examination were taken directly from a book by Hall and associates.[8] Individual BD and AD scores were compared with use of the paired Student *t* tests, and scores were stratified by year of training. Additionally, end of first year AD scores were compared with beginning of second year BD scores, and end of second year AD scores were compared with beginning of third year BD scores by nonpaired Student *t* tests.

Statistical Analysis.—Statistical comparisons were made as previously outlined. Values are reported as mean ± standard error. *P* values of less than 0.05 were considered significant.

RESULTS

Overall, 459 patients in the BD period were compared with 471 patients in the AD period. The case mix was similar in the two study periods (Table 1). During the BD period, 160 of 459 patients (34.9%) were transferred to the MICU from the hospital floor, in comparison with 121 of 471 patients (25.7%) during the AD period.

Acuity of Illness.—Among the 372 patient records reviewed for the acuity of illness (100 patients in the BD period and 272 in the AD period), the APACHE II scores ranged from 2 to 47 (median value, 17; mean ± SE, 17.2 ± 0.8) for the BD period, which was similar to those for the AD period—range, from 0 to 40 (median, 16; mean ± SE, 17.3 ± 0.5). An additional analysis of acuity of illness and outcome

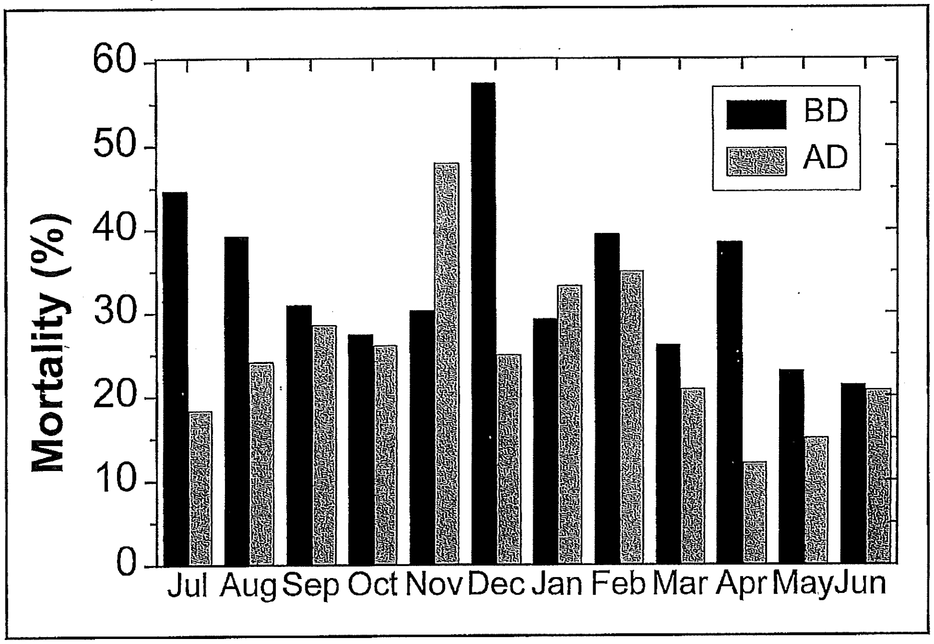

Fig. 1. In-hospital mortality for patients admitted to the medical intensive-care unit for the year before (*dark bars*, 1992 through 1993) (*BD*) and the year after (*light bars*, 1993 through 1994) (*AD*) integration of a full-time intensivist director. These outcome data are presented on the basis of month of admission to the intensive-care unit.

was performed among patients with pneumonia (see subsequent material).

Outcomes.—A 28% reduction in the all-cause mortality rate was noted in the AD period in comparison with the BD period (116 of 471 versus 156 of 459; $P = 0.002$; Table 1). Except for central nervous system diseases, which showed a 41% increase, the mortality rates were reduced or approximately the same for every major disease category in the AD period in comparison with the BD period. Monthly in-hospital BD mortality rates ranged from 21 to 58% (mean, 34.0 ± 3.0%) and exceeded AD mortality rates, which ranged from 12 to 48% (mean, 24.6 ± 2.8%) ($P<0.05$; Fig. 1). In addition, we noted a 29% reduction in deaths occurring in the MICU from 20.9% (96 of 459) during the BD period in comparison with 14.9% (70 of 471) during the AD period ($P = 0.02$).

The all-cause mortality rate for all patients cared for in the MICU for 1991 through 1992 (1 year before the BD period) was 31% and that for 1994 through 1995 (1 year after the AD period) was 21% (Fig. 2). These comparisons were not adjusted for possible differences in age, acuity of illness, and location before ICU admission or transfer. In general, prehospitalized patients had higher mortality than did those who were directly admitted to the MICU (43.8% versus 28.8% during the BD period and 35.5% versus 20.9% during the AD period). During the AD period, mortality rates were reduced in both the prehospitalized (43.8% versus 35.5%) and the directly admitted patients (28.8% versus 20.9%). Of survivors during the BD period, 16.2% were dismissed to nursing homes and 83.8% were dismissed home, in comparison with 20% and 80%, respectively, for the AD period.

An in-depth analysis of a 10% sample of patients from both time periods (all patients admitted to the MICU with pneumonia) revealed no significant differences in distribution of patients by gender, race, or acuity of illness as measured by APACHE II scores. Patients in the AD period tended to be older than those in the BD period (67.0 ± 2.0 years versus 61.5 ± 2.6 years; $P = 0.09$; Table 2). Fewer patients were admitted directly to the ICU from skilled nursing facilities during the BD period (8%) in comparison with the AD period (21%). Patients who were transferred to the MICU from the hospital floor tended to have been hospitalized for a longer duration in the BD period (6.3 ± 1.2 days) than in the AD period (3.6 ± 0.7 days) ($P = 0.06$), but they had lower mean APACHE II scores (17.4 ± 1.7 versus 22.5 ± 1.7; $P<0.05$). The rate at which patients with pneumonia were readmitted to the MICU within 72 hours after transfer to the hospital floors (termed the "rebound rate") was 6% (3 of 52 cases) during the BD period and 7% (4 of 58 cases) during the AD period. The pneumonia-related mortality rate decreased 33%—from 24 of 52 cases during the BD period to 18 of 58 cases during the AD period. These reductions

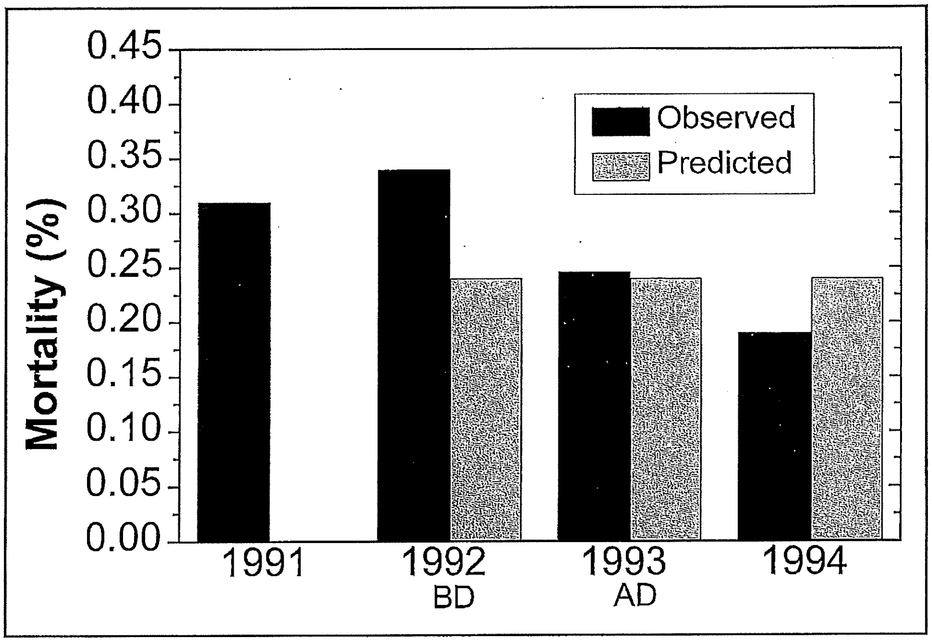

Fig. 2. Observed mean in-hospital mortality (*dark bars*) for patients admitted to the medical intensive-care unit during the periods before (1991 through 1992) (*BD*) and after (1993 through 1994) (*AD*) integration of a full-time intensivist director. Projected mortalities based on acuity of illness (acute physiology and chronic health evaluation or APACHE II scores[9]) for 1992 through 1994 are demonstrated by the *light bars*.

were consistent across categories of APACHE II score, age, race, and gender and were most notable in patients admitted to the MICU directly from home (from 46% during the BD period to 24% during the AD period).

Durations of Stay.—Statistically significant reductions were noted in mean durations of both ICU and total hospital stay during the AD period in comparison with the BD period. The mean duration of ICU stay decreased from 5.0 ± 0.3 days during the BD period to 3.9 ± 0.3 days during the AD period ($P<0.05$). Median stays decreased from 4 days during the BD period to 3 days during the AD period. The rate at which patients required readmission to the MICU within 72 hours after transfer was 6.3% during the BD period and 6.5% during the AD period. The mean duration of total hospital stay decreased from 22.6 ± 1.4 days during the BD period to 17.7 ± 1.0 days during the AD period ($P<0.05$). Median stays decreased from 14 days during the BD period to 11 days during the AD period. Similar reductions were observed for patients with pneumonia during the two periods (Table 2).

Education.—The critical-care in-service examination was administered to 22 medical residents—9 interns, 6 second-year residents, and 7 third-year residents. BD in-service scores ranged from 37.5 to 67.5% (mean, 53.8 ± 1.7%), which were significantly lower than the AD scores of 50 to 85% (mean, 67.5 ± 2.2%) ($P<0.01$). End of first year AD values (66.5 ± 4.0%) tended to be higher than beginning of second year BD values (58.0 ± 3.6%) ($P = 0.14$). End of second year AD values (69.5 ± 4.0%) were significantly higher than beginning of third year BD values (55.4 ± 1.9%) ($P<0.05$) (Fig. 3).

DISCUSSION

The principal findings in this study are that the addition of a medical intensivist's services to a teaching community hospital was temporally associated with reduced patient mortality, reduced MICU and total hospital durations of stay, and improved house staff critical-care knowledge as measured by a standardized examination. The study was limited by our inability to examine patient characteristics and acuity of illness across disease-specific categories. Nonetheless, the consistency of reduction in mortality rates across almost all major disease categories and among both prehospitalized and directly admitted patients, as well as the similar case mix and APACHE II scores during the two time periods, reduces the possibility that favorable patient selection during the AD period explains the foregoing results. In addition, results of the detailed analysis of the pneumonia subcohort support the hypothesis that the reduction in outcome indices during the AD period cannot be explained by differences in patient

Table 2.—**Selected Characteristics and Outcomes for Patients Admitted to the Intensive-Care Unit With a Diagnosis of Pneumonia Before and After Establishment of an Intensivist as Director of Critical Care***

	1992-1993 (BD)		1993-1994 (AD)		
Factor	No.	%	No.	%	*P*
Total cases of pneumonia	52	...	58	...	
Age (yr)†	61.5 ± 2.6		67.0 ± 2.0		0.09
APACHE II score†	20.6 ± 0.9		20.6 ± 0.9		0.97
≤20—deaths	7/24	29	8/33	24	
>20—deaths	17/28	61	10/25	40	
Location before MICU					
Home	37	71	33	57	
SNF	4	8	12	21	
Hospital floor	11	21	13	22	
Mechanical ventilation					
Patients	38	73	39	67	
Mean duration (days)†	11.9 ± 3.2		8.1 ± 1.5		0.31
Median duration (days)	6.5		5.0		
MICU duration of stay (days)					
Mean†	10.3 ± 2.4		7.4 ± 1.2		0.28
Median	6.5		5.0		
Pneumonia-related deaths	24	46	18	31	
Origin-based mortality					
Home	17/37	46	8/33	24	
SNF	2/4	50	4/12	33	
Hospital floor	5/11	45	6/13	46	
Patients rebounding to the MICU within 72 h	3	6	4	7	

*AD = after director; APACHE = acute physiology and chronic health evaluation; BD = before director; MICU = medical intensive-care unit; SNF = skilled nursing facility.
†Data are shown as mean values ± standard error.

characteristics or acuity of illness. Furthermore, the comparable crude MICU all-cause mortality rates for 1991 through 1992 versus 1992 through 1993 and for 1993 through 1994 versus 1994 through 1995 suggest that the reduction in mortality during the AD period was not a trend effect or random occurrence. This reduction in mortality to levels observed at other institutions with full-time trained internists or intensivists[6,10] suggests that it was not the *specific* intensivist but rather the integration of a trained, full-time, on-site physician that contributed to the reductions in mortality among our patients.

Rather than examine a random sample of all diseases, patients with pneumonia from the two time periods were examined in greater detail for possible differences in distribution of potential confounders and effect-modifiers. Analysis of all subjects from a single disease category ensured meaningful numbers for outcome comparison and eliminated possible sampling bias with consequent distorted disease distribution across the two study periods. This subgroup analysis, while confirming the overall trend of results, revealed that the reduction in pneumonia-related deaths was concentrated among subjects admitted to the MICU from home (as distinguished from those admitted to the MICU from skilled nursing facilities or transferred from the hospital floor). We examined the extent to which this pattern could be explained by publication of the American Thoracic Society guidelines for management of community-acquired pneumonia in November 1993.[11] Interestingly, despite emphasis of these guidelines to the attending and resident physicians in winter and spring of 1994, the mortality rate for patients admitted to the MICU with pneumonia was slightly higher after publication of the guidelines (0.34 versus 0.25). Thus, this exogenous factor is unlikely to have contributed to our results.

Two potential explanations might be proposed for reduced mortality during the AD period. First, the intensivist may have directly affected improvements in patient care. Our intensivist, however, provided direct care in less than

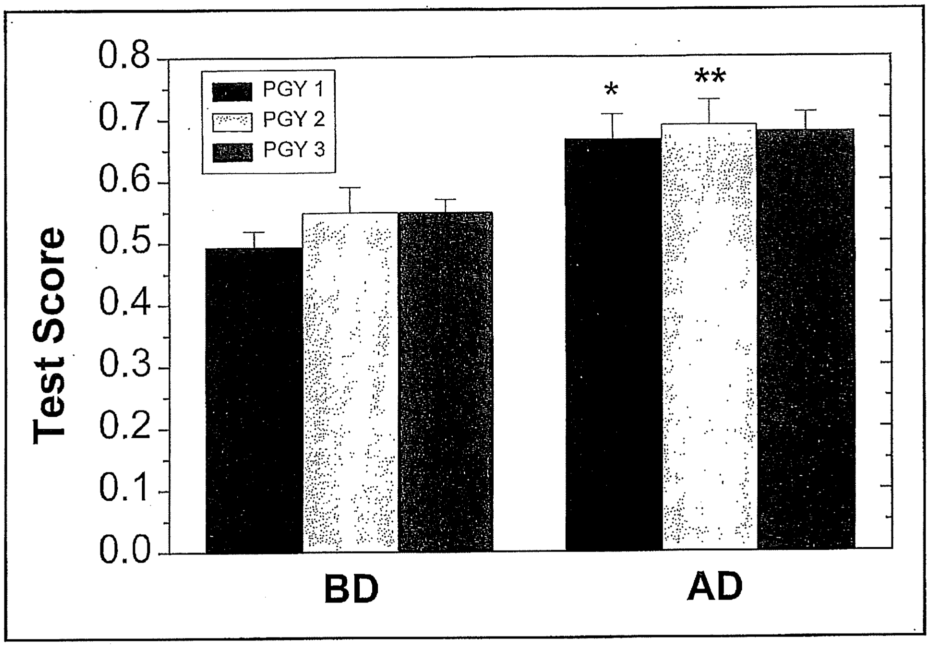

Fig. 3. Mean critical-care in-service examination scores for the year after integration of a full-time intensivist director and institution of a formal critical-care curriculum. * = End of first year after-director (*AD*) values tended to be higher than beginning of second year before-director (*BD*) values ($P = 0.14$). ** = End of second year AD values were significantly higher than beginning of third year BD values ($P<0.05$). *PGY* = postgraduate year.

15% of MICU admissions. Accordingly, a second—and more likely—explanation for reduced mortality is that the intensivist improved house staff education and proficiency with ICU problems or improved ICU organization and interdisciplinary coordination.[10] House staff performance on a standardized critical-care examination significantly improved during the AD period. We believe that our residents were armed with improved knowledge that enabled them to deliver a higher standard of medical care, which was facilitated by improved ICU organization.[10]

The reduction of overall hospital durations of stay cannot be entirely attributed to improved MICU care. During the 2 years of this study, pressure to reduce hospital stays was increased as managed care penetrated our local health-care market. Thus, the reductions in post-MICU stay are unlikely to have been affected by improved MICU care alone. Insofar as no changes occurred in MICU dismissal policies, however, the reductions in MICU stay likely represent the combination of more timely management (by the house staff) and enhanced "bed control" through enforcement of admission and dismissal criteria.

Several previous studies have examined the effect of intensivists on various patient outcomes[5,6] (Table 3). In 1984, Li and associates[5] retrospectively studied the effects of integrating on-site "specialized" university physicians in a community hospital ICU. They found that in-hospital mortality, adjusted for the acuity of illness, significantly decreased in the year AD (in comparison with BD). Unfortunately, they did *not* report the mortality rates for these periods (but provided a *P* value of 0.01). Brown and Sullivan[6] demonstrated that in-hospital mortality was reduced from 35.5% to 24.5%, in patients with similar acuities of illness, with the addition of full-time intensivists to a community tertiary-care facility. In-ICU mortality was reduced from 27.8% to 13.4% during the same period. Note that these findings are similar to our results. In 1988, Reynolds and colleagues[12] compared the effect of critical-care physicians on mortality (in adults) from septic shock in a university hospital. They found that mortality decreased from 74% during the BD period to 57% during the AD period. The use of consultants, resources, and hospital durations of stay were similar for the BD and AD periods. Pollack and coworkers[9] studied the effects of a pediatric intensivist in a university center. Acuity-adjusted mortality decreased by 5% in the AD in comparison with the BD period. A multicenter study of outcome in 5,415 pediatric ICU admissions[13] demonstrated that acuity-adjusted mortality was higher in teaching hospitals (odds ratio of dying = 1.79) and lower in centers

Table 3.—**Summary of Published Studies Documenting the Effect of Intensivist-Guided Therapy on Outcome in Critically Ill Patients***

Study	Design	Sample size (no.)	Population	Findings
Li et al[5]	Retrospective; BD versus AD	954	Adults	Overall IHM tended to decrease, and IHM, adjusted for acuity, was significantly reduced (precise figures were not reported)
Brown & Sullivan[6]	Retrospective	439	Adults	IHM decreased from 35.5% to 24.5%, whereas mortality in ICU decreased from 27.8% to 13.4%
Reynolds et al[12]	Retrospective	212	Adults	Mortality from septic shock decreased from 74% to 57% with the addition of intensivists
Pollack et al[9]	Prospective	262	Children	Acuity-adjusted mortality decreased by 5% in the AD period
Pollack et al[13]	Cross-sectional	5,415	Children	Mortality rate was 54% higher in ICUs without intensivists

*AD = after director; BD = before director; ICU = intensive-care unit; IHM = in-hospital mortality.

with full-time intensivists (odds ratio = 0.65). Study sites were carefully chosen to reduce the likelihood of sampling and observer bias. The increase in mortality at teaching hospitals was attributed to care by trainees (and, in fact, outcomes were worse early during the training year), whereas advanced training and improved coordination of care were hypothesized to account for the reduced mortality associated with intensivist-guided management.[13]

The overt deficiency in most of these studies (the current study included) is that they used historical controls. For a definitive answer to the question of whether hospital-based intensivists improve outcome and efficiency, patients should be prospectively randomized to intensivist-guided versus non-intensivist-guided therapy in the same medical center. Insofar as such a study is unlikely to be performed, inferences regarding cost and outcome efficiencies of intensivist-guided care rely on retrospective studies. Because such investigations are likely to be performed by intensivists, studies demonstrating a positive effect may be more likely to be submitted for publication.

With the foregoing cautions in mind, the outcome and fiscal implications of these findings may nonetheless justify the cost of providing full-time intensivist coverage at many hospitals. We did not have access to the cost of the hospital stays and thus cannot definitively conclude that MICU costs were less in the AD than in the BD period of the current study. Nevertheless, savings derived through reduced MICU length of stay—an average of 1 MICU day/admission—would likely outweigh the total cost of adding an intensivist to the hospital (with the assumption that the intensivist would not use more resources/day).

Pediatricians have concluded that critically ill children should be cared for by an intensivist.[14] No similar consensus has been reached among internists. The Society of Critical Care Medicine and others have suggested that intensivists are cost- and outcome-effective;[15,16] however, few completed studies are available to support this contention in critically ill adults.[5,6,13] Consequently, hospitals have been left to formulate their own solutions, which may not necessarily optimize patient care or minimize cost.

Who is best suited to care for critically ill patients? More than 100 programs[2] have been developed to train physicians from three disciplines (internal medicine, surgery, and anesthesiology) for certification in critical-care medicine. Amidst such developments, can state-of-the-art care be rendered by physicians who have had limited training in this discipline? Moreover, can such patients be cared for by a generalist or subspecialist who is not on-site and immediately available to manage emergencies and titrate therapies? These questions are obviously rhetorical because common sense suggests that a critically ill patient would benefit from the constant vigilance of an on-site physician. In many hospitals, however, this is *not* the model used.[17] Interestingly, we dedicate 24 hours/day nursing and respiratory care in most ICUs, but the constant vigilance of a trained physician is missing from many critical-care units.[17-19] In Connecticut, for instance, only 9 of 25 hospitals with ICUs employ full-time intensivists (as of May 1995). If we accept that intensivists improve patient outcomes and reduce costs, what are potential models that integrate the hospital-based intensivist?

Three commonly used models are available for provision of critical care: (1) open, (2) closed, and (3) semiclosed ICUs. Most ICUs in the United States use the open model, in which any physician with privileges to admit patients to the hospital oversees patient care.[19] This model provides continuity of care, but most generalists and office-based specialists are not readily available to manage emergencies or titrate critical-care therapies. The intensivist sets ICU policy and provides consultations only if requested. In the closed model, the internist yields care of the patient to the intensivist, who manages the critical phase of the patient's care. In the semiclosed system, the generalist maintains close contact with the patient throughout the critical illness, whereas the on-site intensivist manages problems as they arise and acts as a gatekeeper for the allocation of critical-care resources, including requests for additional consultations in other areas of expertise. This system respects the role of the generalist in providing continuity of care while conceding that on-site physicians specifically trained in the management of critically ill patients are best situated to guide therapies and to allocate critical-care resources. The semiclosed or closed formats are likely the most practical solutions for community hospitals.[18]

CONCLUSION

The addition of a full-time intensivist to a community hospital was associated with improved outcomes and expedited care of critically ill patients. Although our study lacks the strength to assert cause and effect, the aggregate of available data may justify the inclusion of hospital-based intensivists in community hospitals.

ACKNOWLEDGMENT

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REF 11: CARSON ET AL

Effects of Organizational Change in the Medical Intensive Care Unit of a Teaching Hospital

A Comparison of 'Open' and 'Closed' Formats

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Objective.—To compare the effects of change from an open to a closed intensive care unit (ICU) format on clinical outcomes, resource utilization, teaching, and perceptions regarding quality of care.

Design.—Prospective cohort study; prospective economic evaluation.

Setting.—Medical ICU at a university-based tertiary care center. For the open ICU, primary admitting physicians direct care of patients with input from critical care specialists via consultation. For the closed ICU, critical care specialists direct patient care.

Patients.—Consecutive samples of 124 patients admitted under an open ICU format and 121 patients admitted after changing to a closed ICU format. Readmissions were excluded.

Main Outcome Measures.—Comparison of hospital mortality with mortality predicted by the Acute Physiology and Chronic Health Evaluation II (APACHE II) system; duration of mechanical ventilation; length of stay; patient charges for radiology, laboratory, and pharmacy departments; vascular catheter use; number of interruptions of formal teaching rounds; and perceptions of patients, families, physicians, and nurses regarding quality of care and ICU function.

Results.—Mean±SD APACHE II scores were 15.4±8.3 in the open ICU and 20.6±8.6 in the closed ICU (P=.001). In the closed ICU, the ratio of actual mortality (31.4%) to predicted mortality (40.1%) was 0.78. In the open ICU, the ratio of actual mortality (22.6%) to predicted mortality (25.2%) was 0.90. Mean length of stay for survivors in the open ICU was 3.9 days, and mean length of stay for survivors in the closed ICU was 3.7 days (P=.79). There were no significant differences between periods in patient charges for radiology, laboratory, or pharmacy resources. Nurses were more likely to say that they were very confident in the clinical judgment of the physician primarily responsible for patient care in the closed ICU compared with the open ICU (41% vs 7%; P<.01), and nurses were the group most supportive of changing to a closed ICU format before and after the study.

Conclusions.—Based on comparison of actual to predicted mortality, changing from an open to a closed ICU format improved clinical outcome. Although patients in the closed ICU had greater severity of illness, resource utilization did not increase.

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INTENSIVE CARE UNITS (ICUs) were created to provide specialized nursing care and monitoring in a consolidated area. Over time, physicians with critical care expertise have become increasingly available. The organization of medical staff in the ICU should facilitate exemplary patient care in the most effective and cost-efficient manner possible.

Most institutions have implemented care by critical care staff with either an "open" or "closed" ICU model.[1-4] In the open system, patients are admitted to the ICU under the care of a primary care physician. In many open ICUs, critical care specialists are available to provide expertise via consultation. In the closed system, patients requiring ICU admission are transferred to the care of the critical care specialist or team. The relative merits of these 2 models of ICU practice are often debated, usually in the absence of data to inform discussion.

Our 600-bed university teaching hospital, situated in an urban community, provides all levels of care to patients from a variety of socioeconomic backgrounds. There is a medical school as well as residency and fellowship training programs in most specialties and medical subspecialties, including pulmonary and critical care. Our 10-bed medical ICU had been organized in an open format, which allowed all medical services to admit patients and write orders in the ICU. The admitting attending physician and house staff under his or her supervision retained primary responsibility for the patient's care. A critical care team examined every patient on a daily basis as a mandatory consult service and made recommendations for management. On February 1, 1994, our ICU changed to a closed format where the critical care team assumed primary responsibility for all patients admitted to the ICU. We sought to use this opportunity to compare the merits of these organizational strategies.

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METHODS

Setting

Open Format.—Patients were admitted to the medical ICU by attending physicians or residents from any of our medical services including general medicine, hematology/oncology, gastroenterology, and neurology. Patients with primary cardiac problems were admitted to a separate coronary care unit and were not included in either portion of this study. Primary responsibility for patient management resided with the admitting attending physician and house staff on that service. An ICU team consisting of a board-certified critical care specialist, a fellow in pulmonary and critical care medicine, a medical resident (postgraduate year [PGY] 2 or 3), 3 medical interns (PGY 1), and 2 to 4 medical students functioned as a mandatory consulting service on all patients admitted to the medical ICU from any service. Daily recommendations for management were made by the ICU team on all patients, but no orders could be written without permission from the primary admitting service. The interns on the ICU team assisted with overnight coverage of the ICU patients on the general medicine, hematology/oncology, and gastroenterology services and had order-writing privileges during those hours only for acute cross-coverage issues. A team of nephrologists rounded on all patients requiring dialysis, and they wrote orders related to dialysis only.

Closed Format.—An ICU team directed by a critical care specialist assumed full responsibility for patients that would have previously been admitted to the ICU by the general medicine, hematology/oncology, gastroenterology, or neurology services. The ICU team now consisted of a board-certified critical care specialist, a fellow training in pulmonary and critical care medicine, 3 medical residents (PGY 2 or 3), 3 medical interns (PGY 1), and 2 to 4 medical students. Order-writing privileges belonged exclusively to the house staff on the ICU team. Members of the original ward service were encouraged to round on their patients after transfer to the closed ICU, but they did not have order-writing privileges. Nephrologists continued to write orders relating to dialysis only.

Critical care specialist staff did not change between study periods. Most of the house staff who were on the ICU team during the closed ICU study period also had admitting privileges during the open ICU study period. Nursing and ancillary personnel remained unchanged as well, as did policies and protocols.

On discharge from the open ICU, the patients would continue to be managed by the physicians who took care of them in the ICU. On discharge from the closed ICU, patients would be transferred to a medical ward service. If a patient had been on a medical ward service prior to admission to the closed ICU, they would be transferred back to the original ward service.

If it was determined that a patient had no chance of recovery from their acute illness and that they should be treated for comfort only, the patients were transferred from the ICU to the medical ward unless it was apparent that their demise was imminent or the intensity of nursing care was too high. The decision to withdraw aggressive care was made by the attending physician on the primary admitting service in the open ICU period and by the attending physician on the ICU team during the closed ICU period.

Study Periods

The study period for the open format was from October 1 through November 30, 1993. The study period for the closed format was from April 1 through May 31, 1994. A 2-month adjustment period was allowed after the initial change in format on February 1, 1994, before data were collected.

Patient Eligibility and Enrollment

There were 124 patients enrolled in the open ICU study period and 121 patients enrolled in the closed ICU study period. All patients admitted to the medical ICU during the study period were eligible for enrollment. If patients had to go to a different ICU because of overload or space problems, they were still followed by the ICU consult team in the open ICU study period, and they were still managed by the ICU team during the closed ICU period. Therefore, these patients were included in the study. Only a patient's first admission during each study period was included to avoid counting 2 outcomes for the same individual. Any patient already admitted to the ICU before the start of either study period was excluded. Data were collected on all patients enrolled during the study periods until the end of their hospital admission.

Measurement of Clinical Outcomes

The Acute Physiology and Chronic Health Evaluation II (APACHE II) system[5] was used to measure severity of illness and predicted death rates for the 2 groups of patients. APACHE II scores for all eligible patients were determined from clinical information obtained during the first 24 hours of admission to the ICU. A total of 42 patients during the first study period and 27 patients during the second study period did not have arterial blood gas measurements during the first 24 hours of their admissions because they had no perceived respiratory or acid-base problems. Therefore, these values were assumed to be normal, and no points were given. All other values were available for all patients in the study except for 1 patient who did not have serum creatinine levels measured. This, too, was assumed to be normal. Chronic health status based on definitions provided in the APACHE II literature[5] was assigned by 2 reviewers after review of each patient's medical record. Diagnostic category weights were assigned to all patients by a single reviewer, using the same criteria for both study periods. Predicted deaths were computed as the sum of individual risks with a multiple logistic regression equation as published by Knaus et al.[5]

Patients were followed during their hospital admission and mortality was determined. Data also were collected for duration of mechanical ventilation until the first extubation, number of patients requiring reintubation (unsuccessful extubations), and number of patients who were ventilator dependent at the time of ICU discharge. The number of patients receiving face mask ventilation were also recorded. Mechanical ventilation data were collected by patient observation or daily examination of patient records. Data indicating which patients received cardiopulmonary resuscitation (CPR) during their hospital admission were obtained from the Cardiopulmonary Resuscitation Subcommittee of the University of Chicago (Ill) Medical Staff, which collects this information daily.

Measurement of Resource Utilization

For each patient in each study period, overall charge data for the laboratory, pharmacy, and radiology departments and total hospital charges were obtained. Charges during the ICU admission as well as pre- and post-ICU admission were examined both separately and in combination. In addition, charges and number of tests ordered were obtained for a group of "indicator tests." The following indicator tests were chosen by the investigators as those whose use was thought most likely to be affected by the change in the organization of the ICU: chest x-ray films, arterial blood gases, complete blood cell counts, and standardized blood electrolyte panels. Length of stay, charges, and test utilization were obtained from the University of Chicago Hospitals' Office of Program Evaluation using the management database of the Burroughs Health Information System.

Changes in hospital charges for tests, laboratory evaluations, and procedures go into effect with the new fiscal year, beginning July 1. Since the study period did not span a change in fiscal year, no significant change in charges occurred between study periods.

A group of indicator drugs was also selected for study on the basis of expected impact from organizational change in the ICU. These included antibiotics, stress ulcer prophylactics, neuromuscular blockers, analgesics, and sedative/hypnotics. Data for number of drugs used and hospital drug cost per patient were obtained by review of pharmacy dispensary records. In determining the number of drugs used in each class, no distinction was made for route of administration.

Data for vascular catheter use, including total number and average duration of use of arterial lines, central venous lines, and pulmonary artery catheters, were collected. Vascular catheter data were obtained from daily examination of patient records, including physicians' and nurses' notes, procedure notes, and nursing care flow charts.

The length of time required to effect patient transfer out of the ICU was recorded for both study periods as an indicator of cooperation and communication between physicians, ICU nurses, and floor nurses.

Interruptions of Formal Teaching Rounds

Under the original open ICU format, an important function of the ICU attending physician was to present a defined syllabus of principles of critical care medicine for house staff and students on the ICU consult team during daily didactic teaching rounds. Formal ward teaching rounds were a part of the daily routine on the medical wards for all primary medical services as well. Interruption of teaching rounds on the wards for patient management issues in the ICU was frequently identified by faculty as an obstacle to teaching.

To objectively assess the effects of organizational change on interruption of formal teaching rounds in the ICU and on the general medicine service, we quantified the number and type of interruptions during teaching rounds for both study periods. One of 3 trained observers attended a sample 10 teaching rounds in the ICU and 10 teaching rounds on 4 different general medicine services. The number and length of interruptions were recorded.

Patient, Family, Physician, and Nurse Perceptions

Eligible patients and 1 family member per patient were interviewed in a standardized manner regarding their perceptions of the following issues related to the care in the ICU: satisfaction with decision making, information access, availability of emotional support, physician-patient relationships, nurse-patient relationships, and perceived level of care. During each study period, patients whose ICU admissions lasted greater than 24 hours were considered eligible for interview. All eligible patients who consented were interviewed unless they were noncommunicative, heavily sedated, or near death. Interviews during both study periods were performed by the same 2 investigators.

Professional staff (including attending physicians from the medical services and the ICU), house staff, and nurses who were employed full-time in the medical ICU completed questionnaires addressing the following issues regarding their perceptions of the change in ICU organization: time commitment and time management, independent and collaborative decision making, education, satisfaction, and factors directly affecting patient care.

Most of the questions in the surveys and questionaires were adapted from those used since 1991 by the 60 members of the University Hospital Consortium, which had been adapted from the well-validated instrument of the Picker Commonwealth Foundation.[6] Questions were presented in Likert-type formats. For questions developed specifically for this project, face validity was assessed by small groups in each respondent category before the research began, and pretests of each instrument were conducted.

Statistical Methods

Data were analyzed using SAS PC (SAS Institute Inc, Cary, NC). Means±SDs are reported, t tests were used to assess differences between means of 2 groups, χ^2 tests were used to test for associations between categorical variables, and logistic regression was used to assess multivariate relationships.

The project was reviewed and approved by the institutional review board.

Table 1.—Mortality and Predicted Mortality*

	ICU Format			
	Open	Closed	95% CI Difference	P
No. of admissions	124	121	. . .	. . .
APACHE II score, mean±SD	15.4±8.3	20.6±8.6	−10.4 to −3.1	.001
Hospital mortality, %	22.6	31.4	−19.9 to 2.2	.12
Predicted mortality, %	25.2	40.1	. . .	. . .
Ratio of hospital mortality to predicted mortality	0.90	0.78	. . .	. . .

*ICU indicates intensive care unit; CI, confidence interval; and APACHE II, Acute Physiology and Chronic Health Evaluation II.

RESULTS

Clinical Outcomes

The patients in the closed ICU had a higher mean±SD age than patients in the open ICU (59±18 years vs 53±19 years; $P<.05$). Sepsis, hemorrhagic shock/hypovolemia, and gastrointestinal bleeding were the most common primary diagnoses during both study periods. There were 13 postoperative patients (10%) in the open ICU and 6 postoperative patients (5%) in the closed ICU. Patients in the closed ICU had higher mean APACHE II scores (20.6±8.6 vs 15.4±8.3; $P=.001$). There was no significant difference between the closed ICU and open ICU in hospital mortality (Table 1).

In the closed unit, the ratio of actual mortality (31.4%) to predicted mortality (40.1%) was 0.78. In the open ICU, the ratio of actual mortality (22.6%) to predicted mortality (25.2%) was 0.90 (Table 1).

Patients who received mechanical ventilation in the closed ICU had significantly ($P=.001$) higher APACHE II scores than mechanically ventilated patients in the open ICU (Table 2), but there were no significant differences between the closed and open ICU in mortality or in duration of mechanical ventilation for survivors. The number of patients either requiring reintubation or unable to be extubated during their ICU admission were similar in both groups. More patients received face mask ventilation in the closed ICU, but the difference was not statistically significant ($P=.18$).

Of the 28 patients who died during their hospital admission in the open ICU period, 25 (89%) did not receive CPR at the time of death. Of the 38 patients who died during the closed ICU period, 33 (87%) did not receive CPR at the time of death. Of the patients who died without receiving CPR, 11 (44%) in the open ICU were receiving mechanical ventilation at the time of death compared with 18 (54%) in the closed ICU. These differences were not statistically significant ($P=.91$).

Resource Utilization

Average ICU length of stay for survivors in the open ICU was 3.9 days, and

Table 2.—Characteristics of Patients Receiving Mechanical Ventilation (MV)*

Characteristic	ICU Format: Open	ICU Format: Closed	P
Patients requiring MV, No. (% admissions)	49 (40)	63 (52)	.06
APACHE II scores for MV patients, mean±SD	20.51 (±8.24)	24.63 (±7.83)	<.001
Mortality for MV patients, %	34.0	46.8	.33
Duration of MV after initial intubation for ICU survivors, h, mean±SD	126.93 (±188.39)	115.96 (±105.5)	.75
No. requiring reintubation	6	3	NC
No. ventilator dependent at ICU discharge	5	4	NC
Face mask ventilation	9	15	.18

*ICU indicates intensive care unit; APACHE II, Acute Physiology and Chronic Health Evaluation II; and NC, not calculated.

Table 3.—Length of Stay*

	ICU Format: Open	ICU Format: Closed	95% CI Difference	P
In unit				
Survivors	3.9±7.0	3.7±3.9	−1.2 to 1.6	.79
All patients	4.4±7.1	4.9±6.3	−2.2 to 1.2	.57
In hospital				
Survivors	14.8±14.8	16.2±15.1	−3.5 to 5.0	.52
All patients	16.7±19.4	15.9±14.2	−5.2 to 2.4	.75

*Data are expressed as mean±SD number of days. ICU indicates intensive care unit; and CI, confidence interval.

Table 4.—Mean Charges per Patient*

	ICU Format: Open	ICU Format: Closed	95% CI Difference	P
Laboratory	1906	1800	−367 to 578	.66
Arterial blood gas	430	467	−117 to 43	.41
Complete blood cell count	69	67	−8 to 12	.66
Kidney profile	126	117	−10 to 28	.38
Radiology	374	431	−195 to 79	.40
Chest x-ray film	262	274	−51 to 27	.58
Pharmacy	1374	1254	−483 to 723	.69

*Data expressed as $/d in intensive care unit (ICU). CI indicates confidence interval.

average length of stay for survivors in the closed ICU was 3.7 days (Table 3). Average ICU length of stay for all patients was 4.37 days in the open ICU and 4.86 days in the closed ICU. Average length of stay in the hospital for survivors including ICU days was 14.8 days in the open ICU and 16.2 days in the closed ICU. Hospital length of stay for all patients was 15.9 days in the closed ICU and 16.7 days in the open ICU. None of these differences were statistically significant.

When comparing mean charges per patient per unit day for laboratory, radiology, and pharmacy resources, there were no differences noted between the closed and open ICU periods (Table 4). There were also no differences between charges for the laboratory and radiology indicator tests. No statistically significant differences were noted when charges were stratified by APACHE II score or hospital survival (data not shown). There were significant increases, however, in the use of neuromuscular blockers and sedative/hypnotic drugs in the closed ICU (Table 5) as determined by the number of drugs used in each category (as well as actual drug cost per patient for sedative/hypnotic drugs). Use of antibiotics, stress ulcer prophylactics, and analgesics were similar in the open and closed ICU study periods.

In regard to vascular catheter use, more patients received arterial lines, central venous lines, and pulmonary artery catheters in the closed ICU (Table 6), and they were used for a longer average duration.

Occupancy rate in the medical ICU was 76% for the open ICU study period and 95% for the closed ICU study period. Nurse/patient ratios were maintained at 1:1 or 1:2 at all times. Staffing was adjusted each shift based on occupancy. The average time required for transfer of patients out of the ICU after notification of the floor nurse decreased from 280 minutes in the open ICU to 241 minutes in the closed ICU. In addition, there were 30 instances of transfers being canceled after notification of the floor nurse in the open ICU compared with only 4 instances in the closed ICU.

Interruption of Formal Teaching Rounds

Formal ICU teaching rounds were interrupted for ICU patient issues much more frequently and for longer periods of time in the closed ICU (124 interruptions; mean duration, 21.2 minutes) compared with the open ICU (28 interruptions; mean duration, 7.0 minutes). Total minutes of formal teaching rounds observed in the closed ICU (659 minutes) were significantly less than in the open ICU (1231 minutes) because patient care responsibilities necessitated discontinuation of many didactic sessions. General medicine teaching rounds were not significantly affected by the change in ICU organization.

Patient and Family Perceptions

There were 92 eligible patients in the first study period, of which 52 patients and 48 families were interviewed. Of the 52 patients interviewed in the first study period, 30 had families available for interview. There were 94 eligible patients in the second study period, of which 50 patients and 49 families were interviewed. Of the 50 patients interviewed in the second study period, 31 had families available for interview. The number of persons who responded to each question varied slightly, and missing values are excluded from proportions reported. Seventy-five percent of patients interviewed in the first study period and 82% of patients interviewed in the second study period had APACHE II scores greater than 10.

Decision Making.—Although most patients and families (>67%) indicated that they agreed with decisions made about the patient while in the ICU, more than 20% of patients and families in both formats indicated that they wished to be more involved in decision making regarding their care. In both study periods, 30% of patients stated that they were not at all involved in decisions made about their care. There were not significant differences between the study periods.

Information Access.—More families in the closed than the open format said that it was very easy to find a doctor to talk with (66% vs 41%; $P<.05$). In both formats, however, greater than 60% of the families interviewed stated that the nurse was the individual most likely to answer questions and address concerns about the patient's medical situation.

Availability of Emotional Support.—More patients in the closed format reported that it was hard or very hard to find someone on the unit staff to provide emotional support (39% vs 20%; $P<.05$) and often "too little emotional support" was offered in the closed unit (39% vs

Table 5.—Indicator Drugs*

Indicator Drugs	ICU Format: Open	ICU Format: Closed	95% CI Difference	P
Mean No. per patient per ICU admission				
Antibiotics	2.53	2.61	−0.60 to 0.76	.81
Stress ulcer prophylactics	1.03	1.17	−0.04 to 0.32	.11
Neuromuscular blockers	0.10	0.22	0.06 to 0.23	.03
Analgesics	0.73	0.94	−0.01 to 0.43	.06
Sedative/hypnotics	0.80	1.19	0.10 to 0.69	.008
Total	5.20	6.14	−0.18 to 2.06	.09
Cost per patient, $/d				
Antibiotics	250.77	232.76	−111.04 to 147.05	.78
Stress ulcer prophylactics	29.42	32.23	−8.98 to 14.59	.63
Neuromuscular blockers	25.76	76.69	−62.82 to 164.67	.37
Analgesics	3.82	5.25	−1.31 to 4.16	.30
Sedative/hypnotics	123.98	255.82	10.99 to 252.69	.03
Totals	433.75	602.75	−124.28 to 462.26	.25

*ICU indicates intensive care unit; and CI, confidence interval.

Table 6.—Vascular Catheter Use for Open and Closed Intensive Care Unit (ICU) Formats

	ICU Format: Open	ICU Format: Closed	P
No. of patients receiving lines			
Arterial line	65	78	.07
Central venous line	37	56	.02
Pulmonary artery catheter	23	41	.002
All lines	74	90	.02
Average duration per line, h			
Arterial line	70	80	.23
Central venous line	78	99	.07
Pulmonary artery catheter	67	74	.92
All lines	73	86	.04

12%; $P<.05$). In both formats, patients and families perceived nurses to provide the bulk of emotional support.

Perceived Level of Care.—In the open ICU, 44.2% of patients and 45.8% of families evaluated patient care as excellent compared with 52.1% ($P=.06$) and 59.2% ($P=.26$) in the closed ICU.

Physician and Nurse Perceptions

Response rate to questionaires in the open ICU study period were as follows: nurses, 94%; house staff, 83%; and attendings, 100% (including 16 ward attendings and 2 critical care physicians). In the closed ICU study period, the response rates were as follows: nurses, 85%; house staff, 78%; and attendings, 73% (including 13 ward attendings and 3 critical care physicians). The number of persons who responded to each question varied slightly, and missing values are excluded from proportions reported.

Continuity of care was rated as poor by none of the house staff or attending physicians in the open ICU compared with 23.8% ($P<.001$) and 33.3% ($P<.05$), respectively, in the closed ICU. House staff responded that the ICU service was very important in making patient care decisions in the closed system compared with the open system (95% vs 39%; $P<.01$). With regard to independence in making patient care decisions, 5% of house staff in the open ICU felt that they needed more independence compared with 41% in the closed ICU ($P<.05$). Opportunities to learn were rated as poor by 2% of the house staff in the open ICU compared with 23% in the closed ICU ($P<.05$), and opportunities to teach were rated as poor by 5% of house staff in the open ICU compared with 32% in the closed ICU ($P<.05$). However, 43% of house staff reported being very comfortable in managing ICU patients after rotations in the closed system compared with 24% in the open system ($P<.05$). Also, 52% of house staff in the closed system rated their level of experience in managing ICU patients as "very experienced" compared with 15% in the open ICU ($P<.05$).

There were few statistically significant differences between responses to questionnaires by nurses. However, nurses were more likely to say that they were very confident in the clinical judgment of the physician primarily responsible for patient care in the closed system compared with the open system (41% vs 7%; $P<.01$).

When asked directly if they support the change to a closed format, 55% of attending physicians responded as being supportive or very supportive before the change compared with 33% ($P=.71$) after the change. Sixty-nine percent of house staff and 93% of nurses were supportive or very supportive before the change compared with 70% ($P=.71$) and 86% ($P=.23$), respectively, after the change.

COMMENT

A nationwide survey in 1991[1] of American Hospital Association–registered hospitals revealed that 22% of the responding hospitals' ICUs used a closed format in which only ICU staff could write orders on ICU patients. Fifteen percent of the respondents indicated that patients were transferred to the service of the medical director of the unit on admission to the ICU. Larger hospital size, more specialized units, and medical school affiliation had the greatest influence on creation of closed ICUs. The relative merits of open or closed ICUs have been vigorously debated,[3] but data on the subject have not been available.

Several studies of individual ICUs demonstrated decreased ICU mortality when specialists trained in critical care were added to ICU physician staff either as consultants[7] or primary physicians[8-10] when specialist input previously had not been available. Three of the studies[8-10] documented an increase in utilization of monitoring devices such as pulmonary artery catheters and arterial catheters after involvement of critical care specialists.

An extensive study by Knaus et al[11] examined 13 hospitals with 3 different ICU organization and staffing patterns: level I units had full-time directors, high nurse-to-patient ratios, and a strong commitment to research; level II units had part-time directors and qualified designates in the hospital at all times, and high to intermediate nurse-to-patient ratios; and level III units had part-time directors who relied on other in-house physicians for coverage and had low nurse-to-patient ratios. They prospectively compared ratios of actual mortality to predicted mortality based on APACHE II scores in 5030 ICU patients. There were no significant differences in mortality ratios between level I and level II or level III ICU organization types. One of the hospitals had a significantly better mortality ratio than the other hospitals as a group. That hospital's ICU was staffed by senior-level in-house physicians and had high levels of physician-staff interaction and communication. Clinical protocols were prominently used, and that facility had the highest number of therapeutic interventions such as chest physical therapy and laboratory testing.

To our knowledge, there have been no reports in the literature evaluating the effect of a change in ICU organization from an open to a closed format on patient outcome or resource utilization without the confounding influences of institutional differences or additions of critical care specialists to physician staff. In our institution, on changing from an open to a closed ICU format, critical care specialists who had previously served as consultants assumed direct responsibility for patient management. We then prospectively studied the effects of these changes on important aspects of ICU function, including patient outcome, resource utilization, and teaching. In addition, we attempted to assess the effects of the organizational change on patient care and professional collaboration by collecting qualitative perception data from patients, their families, physicians, and nurses.

To compare clinical outcomes between groups of ICU patients with differing severity of illness, we used the APACHE II system to calculate predicted mortality for patients in both study periods. APACHE II uses 12 physiologic variables measured during the first 24 hours of admission as well as age and chronic health status to calculate APACHE II scores. These scores have been shown to correlate well with risk of subsequent hospital death.[5] By assigning each patient a principle diagnosis that led to ICU admission and factoring in whether patients are admitted after emergency surgery, the expected death rate can be calculated using a regression analysis equation provided by Knaus et al.[5] Validation of this system revealed an overall correct classification rate of 88.5% for individuals with a 0.50 predicted risk of death.[5]

Patients admitted to the closed ICU during our study were older and had a significantly greater level of illness severity. Comparison of actual and predicted mortality revealed that actual mortality was lower than predicted during the open and closed ICU study periods. However, this difference was greater in the closed ICU, indicating a better overall clinical outcome. Results for both study periods compare favorably with data obtained from other institutions.[11]

It is unclear why patients admitted during the closed ICU study period had greater severity of illness. The closed ICU team may have been more selective as to which patients needed intensive care. They also may have been influenced by a higher ICU occupancy rate during the second study period, which would have made it less likely that patients with borderline severity of illness would be admitted to the ICU. Another possibility is that primary physicians on the medical wards may have been reluctant to send patients with borderline severity of illness to the ICU because they did not wish to disrupt established physician-patient relationships. Finally, the differences in ICU disease severity between study periods may reflect random or seasonal differences in community disease patterns.

Patients receiving mechanical ventilation were selected as a subgroup for clinical outcome because such patients required the most input from the ICU team when they served as consultants in the open format. Although improved clinical performance in this area was expected in the closed ICU, mortality and other measures of clinical outcome for mechanically ventilated patients did not differ significantly between the open and closed ICU. However, it should be noted that mechanically ventilated patients in the closed ICU had greater severity of illness. Use of the APACHE II system to predict mortality for mechanically ventilated patients as a subgroup has not been validated. Hospital mortality for patients receiving mechanical ventilation under either format (34.0% open and 46.8% closed) compares favorably with overall mortality rates of 38% to 64% that are reported in the literature for mechanically ventilated nonoperative patients.[12-17] Duration of mechanical ventilation is an important measure to follow because of resource implications,[18] but wide variations between patients make conclusive data difficult to obtain unless adjusted for disease type.

The small number of patients who received CPR at the time of death (11% of the open ICU patients and 13% of the closed ICU patients) indicates an awareness by physicians in both ICU formats that patients having a grave prognosis would not benefit from CPR. Many of those patients still received rather aggressive care as evidenced by the fact that approximately half of them were receiving mechanical ventilation at the time of death. The type of ICU format was not a factor. Similar findings from another university-based medical center have been reported by Prendergast and Luce.[19] They found that CPR was initiated in 10% of deaths in their medical and surgical ICUs. Of the 90% of deaths that were preceded by a decision to limit life-saving medical treatment, 71% received life support measures but had them withdrawn, 6% had life support continued but died without attempts at resuscitation, and 14% had all life support measures withheld. They also noted that this was a significant change in practice from 5 years earlier when CPR was initiated in 49% of deaths in the same ICUs.

Intensive care unit and hospital lengths of stay were unchanged between the open and closed ICU formats despite the greater severity of illness in the closed ICU. There were no major changes in hospital admitting policies between study periods that could have affected ICU length of stay. The ICU length of stay in the second study period may have been affected by the higher occupancy rate by creating increased pressure to discharge patients to make beds available for new admissions.

Nurse-patient ratios were 1:1 or 1:2 at all times. Staffing was adjusted each shift based on occupancy. Although the occupancy rate was higher in the closed ICU period, total admissions and length of stay were similar for both study periods. This would indicate that much of the increased occupancy in the second study period is accounted for by patients from nonmedical ICUs that "overflowed" into the medical ICU. Those patients were not managed by the ICU service, and they were not included in the study. Therefore, physician-patient ratios remained nearly the same in both study periods, and care should not have been affected.

Despite the greater severity of illness of patients in the closed ICU, most measures of resource utilization in terms of laboratory, radiology, and pharmacy charges showed no differences between the closed or open ICU. The greater use of face mask ventilation, sedative/hypnotic drugs, neuromuscular blockers, and central lines in the closed ICU probably reflect differences in the severity of illness between the patient groups. This trend may also reflect differences in therapeutic approach by the intensivists and possibly a greater level of comfort with such measures by the house staff when under direct supervision of the intensivists. Increased use of central lines and neuromuscular blockers would be expected to improve patient outcome only if used for appropriate indications, but indications for their use were not evaluated in this study.

Although most of the house staff on the closed ICU team had admitting privileges to the open ICU for 2 months between the open and closed ICU study periods, they only would have managed an average of 6 patients each during this time. We feel that this limited amount of ICU patient contact for house staff between study periods had little impact on differences in patient outcome. House staff in the closed ICU managed significantly more critically ill patients over a month than they would have in the open ICU, and this most likely accounts for their perception that they felt more experienced in managing critically ill patients after their closed ICU rotation.

Frequent interruption of teaching sessions has been identified as an important obstacle to establishing an effective educational environment in a teaching hospital.[20-22] When the ICU team was changed from a consult service to a primary service with direct patient care responsibilities, there was less time overall for formal teaching rounds, and rounds were interrupted significantly more often for patient management issues. The house staff also indicated on questionnaires that they had less time to learn and teach in the closed ICU. However, house staff reported higher levels of comfort in managing critically ill patients after a closed ICU rotation compared with their experience in the open ICU. This perception could be attributed to closer contact with critical care specialists during work rounds and during decision-making processes in the closed ICU. It could also be attributed to the larger number of ICU patients that they were able to manage during their closed ICU rotation. The relative value of didactic teaching vs hands-on experience in learning how to manage critically ill patients should be the subject of more focused studies in the future. Also, our data do not indicate how comfortable house staff would be in managing patients in the ICU if they experience long breaks between closed ICU rotations. This would compare with the open ICU format where they manage a few patients in the ICU during every month that they are on a clinical rotation.

Attending physicians on the medical wards and house staff indicated that continuity of care for patients was significantly interrupted by admitting them to a closed ICU. Although those physicians had the opportunity to visit the patients on rounds while they were in the ICU, if they weren't directly responsible for the rapid pace of therapy and response they inevitably would be less informed and less involved in decisions. Detailed communication between physician teams when patients are transferred in or out of a closed ICU can help overcome this loss of continuity, but this requires significant effort from each physician.

Nurses reported a higher level of confidence with the clinical judgment of physicians primarily responsible for patient management in the closed ICU compared with the open ICU. This finding as well as the high level of support from the ICU nurses in favor of the closed ICU format is notable considering the relatively large amount of ICU care provided by nurses. The improvement in efficiency of transfer of patients out of the ICU may indicate an improvement in communication between physicians and nurses in the closed ICU.

Patient and family satisfaction improved slightly with the closed ICU format. Physicians were perceived to be more available to answer questions for patients and families in the closed ICU, but more patients in the closed ICU reported difficulty finding someone from the ICU staff to provide emotional support. Nurse-patient and physician-patient ratios did not change, so this might be attributed to the higher acuity of illness allowing less time for nurses and physicians to attend to patients' emotional needs. Interrupted continuity of care affecting physician-patient relationships may have been a factor also. Patients in both study periods identified nurses as the caregivers most likely to provide emotional support.

An unexpected finding during both study periods was that 30% of patients who were interviewed in the ICU stated that they were not at all involved in decisions made about their care. This suggests that physicians underestimate the ability of critically ill patients to participate in their own care. Awareness of this issue by physicians should result in more determined efforts to involve patients in decision making while they are being cared for in an ICU.

In summary, changing from an open to a closed ICU format improved clinical outcome for patients managed in an ICU that had already been functioning at a highly effective level. Despite the higher severity of illness of patients admitted to the closed ICU, the improvement in clinical outcome was achieved without an increase in resource utilization. Although formal teaching of house staff was interrupted more frequently in the closed ICU, house staff ultimately felt more comfortable and experienced in managing critically ill patients. Nurses were supportive of changing to a closed ICU format, in part because of higher confidence in the clinical judgment of the physician primarily responsible for patient care in the closed ICU. Overall patient and family satisfaction improved in the closed format, but patients from both formats identified a lack of involvement in decision making.

We believe these data support the use of a closed ICU organizational format in comparable clinical settings. We are reluctant to generalize this observation to environments that differ substantially in staffing, particularly nonteaching facilities. Further studies in these institutions are required. A longer study period with higher patient numbers may have provided more conclusive data regarding outcomes of mechanical ventilation, length of stay, and resource utilization. Finally, we have identified didactic teaching and preservation of patient-physician relationships as areas requiring special attention following change from an open to a closed ICU organizational format.

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REF 12: NEURAZ ET AL

Patient Mortality Is Associated With Staff Resources and Workload in the ICU: A Multicenter Observational Study.

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Objective: Matching healthcare staff resources to patient needs in the ICU is a key factor for quality of care. We aimed to assess the impact of the staffing-to-patient ratio and workload on ICU mortality.
Design: We performed a multicenter longitudinal study using routinely collected hospital data.
Setting: Information pertaining to every patient in eight ICUs from four university hospitals from January to December 2013 was analyzed.
Patients: A total of 5,718 inpatient stays were included.
Interventions: None.
Measurements and Main Results: We used a shift-by-shift varying measure of the patient-to-caregiver ratio in combination with workload to establish their relationships with ICU mortality over time, excluding patients with decision to forego life-sustaining therapy. Using a multilevel Poisson regression, we quantified ICU mortality-relative risk, adjusted for patient turnover, severity, and staffing levels. The risk of death was increased by 3.5 (95% CI, 1.3–9.1) when the patient-to-nurse ratio was greater than 2.5, and it was increased by 2.0 (95% CI, 1.3–3.2) when the patient-to-physician ratio exceeded 14. The highest ratios occurred more frequently during the weekend for nurse staffing and during the night for physicians ($p < 0.001$). High patient turnover (adjusted relative risk, 5.6 [2.0–15.0]) and the volume of life-sustaining procedures performed by staff (adjusted relative risk, 5.9 [4.3–7.9]) were also associated with increased mortality.
Conclusions: This study proposes evidence-based thresholds for patient-to-caregiver ratios, above which patient safety may be endangered in the ICU. Real-time monitoring of staffing levels and workload is feasible for adjusting caregivers' resources to patients' needs. (*Crit Care Med* 2015; XX:00–00)
Key Words: intensive care units; medical staffing; mortality; multilevel modeling; nurse staffing

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Matching healthcare staff resources with patients' needs is a key factor to maintain safe care in ICUs. Adequate patient-to-nurse (P/N) and patient-to-physician (P/P) ratios may be associated with higher survival rates and a lower risk of failure to rescue (1, 2). However, the optimal ratios have not been completely established. An optimal ratio should be that above which a significant deterioration in patient outcome is observed. Although arbitrary thresholds have been set, these recommendations are based on experts' opinions rather than on scientific evidence (3–6). Several studies assessing the influence of nurse staffing on mortality resulted in inconsistent findings (7–14). Some works found a significant association between mortality and P/N ratio (7, 10–13), but others did not (8, 9, 14–16). Even though it is commonly accepted that the physician staffing level affects mortality, no objective P/P ratio has been worked out to date (17).

Although it is commonly believed that patient mortality is influenced by the number of caregivers in charge of patient care, there is a lack of evidence to support this assumption. In principle, to guarantee consistent patient outcomes, staff resources should continuously mirror the burden of workload that intensive care teams are facing. In addition to staffing levels, patient severity and volume of life-sustaining procedures were performed; the workload is traditionally estimated based on patient turnover (18–20). Here, we assumed that both the staffing level and the burden of clinical activity may influence ICU patients' outcomes. We used a shift-by-shift varying measure of patient-to-caregiver ratios in combination with workload assessment to establish their relationships with ICU mortality over time.

METHODS

Study Design and Data Sources

We performed a multicenter longitudinal study in eight adult ICUs located in four university hospitals in Lyon, France. Of the eight ICUs, two were mostly medically oriented, four were mostly surgically oriented, and two were mixed medical-surgical units. All were closed ICUs directed by anesthesiologists, medical intensivists, or mixed medical teams.

Three large databases used for routine tasks were merged to accurately establish where and when caregivers worked and patients were treated: 1) claims data used for billing inpatient stay, 2) the day-by-day, hour-by-hour planning of medical and nurse staff databases, and 3) the human resources database containing information about qualifications and affiliations of staff members. In addition, we reviewed the medical records of every deceased patient to accurately identify any decision to forego life-sustaining therapy (DFLST) during the ICU stay. According to the French law, our study was exempt from approval per local ethics committee.

Information pertaining to every patient admitted to these ICUs between January 1 and December 31, 2013, was used in the present analysis. Standard discharge abstracts for every hospitalization contained compulsory information about patients (ie, gender, age, and residence), admission context (ie, emergency status, surgical, or medical care), the Simplified Acute Physiology Score (SAPS) II (21) measured over the first 24 hours of ICU admission, a selection of life-sustaining medical procedures (LSP; eg, mechanical ventilation, vasopressive drugs, renal replacement therapy, and extracorporeal membrane oxygenation), and 31 coexisting conditions extracted from the Elixhauser list of comorbidities (22).

We extracted caregiver presence at work on an hourly basis for each ICU employee (ie, nurses and physicians) and for each day of the study period. Work was mainly organized on a 12-hour basis but, during the day, additional staff with varying work hours could be present. To minimize staffing variations observed during each period while maintaining a sufficient granularity, shift was selected as a temporal unit for analysis. A shift was split into the following four time frames: 7:00 AM to 0:59 PM, 1:00 PM to 6:59 PM, 7:00 PM to 0:59 AM and 1:00 AM to 6:59 AM.

Main Outcome and Key Predictors

The primary outcome was mortality at time of ICU discharge by shift, excluding patients for whom a DFLST was made. Primary outcome was initially adjusted for age, gender, admission context, emergency status, SAPS II, and comorbidities.

Apart from these common confounding factors, the staffing and the caregiver workload were used as key predictors. Nurse and medical staffing were defined as P/N and P/P ratios, respectively, by shift. We split P/N into the following five categories: less than or equal to 1:1, greater than 1:1 to less than or equal to 1.5:1, greater than 1.5:1 to less than or equal to 2:1, greater than 2:1 to less than or equal to 2.5:1, and greater than 2.5:1 (2:1 meaning two patients for one nurse). The following four categories for P/P were defined as follows: less than or equal to 8:1, greater than 8:1 to less than or equal to 10:1, greater than 10:1 to less than or equal to 14:1, and greater than 14:1 (10:1 meaning 10 patients for one physician). Medical residents were included in the count of physicians. We calculated the resident-to-physician ratio (R/P) as the number of residents divided by the number of physicians.

Two additional metrics were used to describe workload. The turnover of patients was measured by dividing the cumulative number of ICU admission and ICU discharge (excluding deaths) during a shift with the number of patients actually staying in the ICU during that shift (20). The mean number of LSPs per patient performed during a shift was also considered a marker of both the workload and the patient severity. We reasoned that the higher the LSP number, the higher the number of procedures performed by the team and presumably the higher the number of failing organs.

Statistical Analysis

Categorical variables are presented using absolute and relative frequencies and were compared using the chi-square test. Continuous variables are presented using mean and one SD and were compared using the Mann-Whitney *U* test. Shifts with missing values regarding staffing resources were not included in the analyses.

To explore the determinants of ICU mortality per shift and to adjust for site in analysis, we performed multilevel Poisson regression taking into account the clustering effect of patients within the ICU (23). Death was the outcome of interest in the model, while staffing and workload were the main predictors. To control for potential confounding variables, patients' characteristics were a priori selected as clinically important covariates. The proportion of surgical cases versus medical cases was used to adjust on the type of patient case-mix admitted to ICU. The final multivariate model included the following variables: P/N, P/P and residents-to-physicians ratios, patient turnover, number of LSP, proportion of men, proportion of surgical cases, SAPSII, and number of comorbidities. The results are presented as adjusted relative risks with their corresponding 95% CIs. Potential variations over time in the highest values of P/N and P/P ratios, as well as patient turnover, are described according to shifts and calendar days. All analyses were performed using R version 3.02 and the package lme4 (glmer function) (24, 25).

RESULTS

Population and Shifts Description

A total of 5,718 patients were hospitalized in eight ICUs during the 1-year study period (**Table 1**). The mean number of patients per shift ranged from 8.3 to 22.2 according to ICU size. Overall, 67% of them were men, aged 60.6±6.3 years, and SAPSII was 50.5±10.6 with an average of 2.2 comorbidities per patient. Regarding the

TABLE 1. Description of Studied ICUs

	Hospital A		Hospital B		Hospital C		Hospital D		
	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Total
	$n = 393$	$n = 973$	$n = 578$	$n = 353$	$n = 647$	$n = 1,520$	$n = 590$	$n = 644$	$n = 5,718$
No. of deaths	86 (22%)	114 (8.5%)	138 (23%)	68 (19%)	69 (11%)	127 (8%)	155 (26%)	94 (14%)	851 (15%)
No. of deaths (no decision to forego life-sustaining therapy)	41 (10%)	36 (3%)	53 (9%)	25 (7%)	44 (7%)	110 (7%)	72 (12%)	43 (7%)	424 (7%)
Description of staff (per shift):									
Mean patients-to-nurse ratio (SD)	2 (0.5)	1.7 (0.5)	1.7 (0.3)	1.6 (0.3)	1.6 (0.3)	1.7 (0.3)	2 (0.4)	1.9 (0.5)	1.8 (0.4)
Mean patients-to-physician ratio (SD)	5.1 (3.3)	4.5 (2.2)	6.0 (5.2)	3.2 (1.4)	5.9 (3.4)	9.5 (3.3)	7.2 (4.9)	3.9 (1.9)	5.6 (3.2)
Description of workload (per shift)									
Mean patient turnover (SD)[a]	5.8 (9.3)	10 (11.0)	7.1 (9.4)	5.8 (9.2)	5.1 (6.6)	8.4 (9.8)	5.6 (7.6)	7.5 (10.0)	6.9 (9.0)
Mean number of life-sustaining procedure (SD)b	1.3 (0.4)	1.2 (0.3)	1.6 (0.3)	1.8 (0.3)	0.9 (0.2)	1.3 (0.2)	1.2 (0.2)	1.1 (0.3)	1.3 (0.3)
Description of patients (per shift)									
Mean number of patients (SD)	8.3 (1.4)	12. 5(2.7)	11.9 (2.6)	8.7 (1.3)	17.0 (2.6)	22.2 (4.3)	12.2 (2.2)	11 (2.2)	13.3 (5.1)
Mean proportion of men (SD)	0.7 (0.2)	0.7 (0.1)	0.7 (0.1)	0.7(0.17)	0.6 (0.1)	0.6 (0.1)	0.6 (0.1)	0.7 (0.2)	0.7 (0.1)
Mean age (SD)	63.8 (5.5)	56.4 (6.4)	63.6 (5.5)	60.6 (4.4)	53.9 (3.6)	61.4 (3.2)	65.8 (5.6)	58.4 (5.3)	60.6(4.9)
Mean proportion of surgical cases (SD)	0.5 (0.2)	0.7 (0.1)	0.2 (0.1)	0.7 (0.1)	0.8 (0.1)	0.9 (0.1)	0.2 (0.1)	0.7 (0.1)	0.6 (0.1)
Mean Simplified Acute Physiology Score II (SD)	55.5 (6.9)	52.8 (6.1)	46.4 (6.1)	58.2 (8.8)	36.4 (4.3)	49.8 (5.0)	62.4 (6.1)	52.7 (8.0)	50.5(6.4)
Mean number of comorbidities (SD)c	2.6 (0.8)	2.8 (0.6)	1.9 (0.5)	2.1 (0.5)	1.9 (0.4)	2.4 (0.5)	2.3 (0.5)	1.8 (0.5)	2.2 (0.5)

[a]Number of admissions plus discharges (excluding death) over the census during the shift, in percentage.
[b]Mean number of life-sustaining procedures per patient-day.
[c]Conditions extracted from the Elixhauser list of comorbidities (22).
Deaths with and without decision to forego life-sustaining therapy are described with their number and proportion; all other variables are described with their mean/proportion and SD.

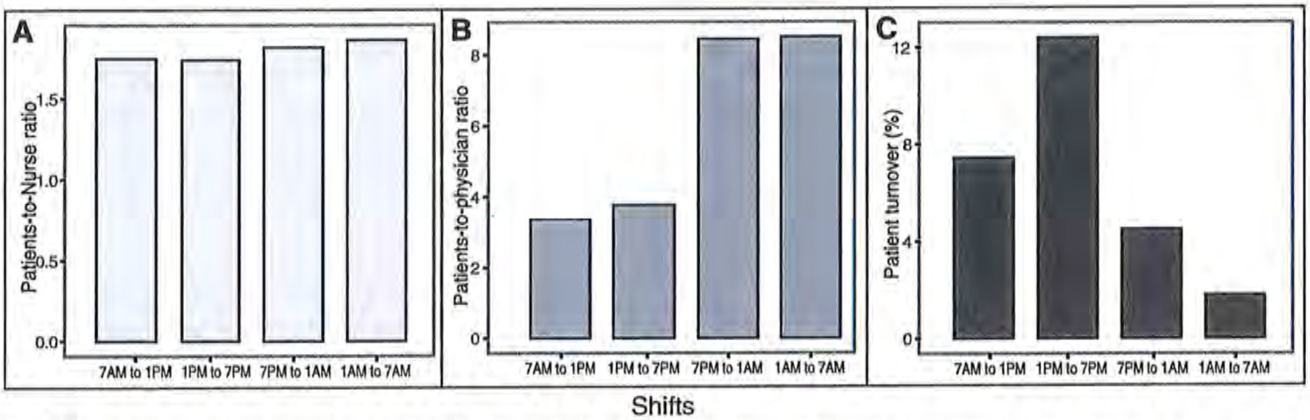

Figure 1. Ratios of patients per nurse and per ICU physician and patient turnover by shift. **A**, Patients-to-nurse ratio. **B**, Patients-to-physician ratio. **C**, Patient turnover.

workload, there were 1.3 LSPs per patient-shift and a mean patient turnover of 6.9%. The overall mortality rate was 14.9% (851/5,718) and 7% (424/5,718) of deaths occurred without a DFLST order.

The mean P/N was stable across the shifts, with an average of 1.8 patients per nurse (**Fig. 1*A***). On the contrary, P/P varied dramatically between day and night shifts, with a mean of 3.6 patients per physician during the day versus 8.5 during the night (**Fig. 1*B***). The turnover varied depending on the hour of the day. It was maximal during the day shifts, with a mean of 9.9 between 7:00 am and 6:59 pm, and lower during night shifts, with a mean of 3.2 between 7:00 pm and 6:59 am (**Fig. 1*C***).

Relationship of Patients to Caregivers' Ratio and ICU Mortality

A total of 11,666 shifts in the eight ICUs were studied over 1 year (14 shifts with missing values were not included in the analysis), including 415 shifts during which at least one death occurred (**Table 2**). The fully adjusted model, taking into account both staffing and workload levels, showed an increased risk of mortality, with the highest values for P/P and P/N. The ICU risk of death increased by a factor of 3.5 (1.3–9.1) when the number of patients was above 2.5 per nurse and by a factor of 2.0 (1.3–3.2) when the number of patients was above 14 per physician. The presence of medical residents did not influence inpatient mortality ($p = 0.6$). Patient turnover supported a adjusted relative risk of 5.9 (2–15) for ICU deaths. SAPSII and LSP were also associated with increased ICU mortality.

The highest values of P/P (ie, > 14 patients per physician) were represented during 3% of the time shifts and occurred mainly at night (87% vs 13%; $p < 0.001$) (**Fig. 2*A***). The highest values of P/N (ie, > 2.5 patients per nurse) affected 5% of the time shifts. These were uniformly distributed across the day ($p = 0.53$) (**Fig. 2*B***) but occurred more frequently during the weekend ($p < 0.001$) (**Fig. 3*B***).

DISCUSSION

This multicenter study proposes evidence-based thresholds of five patients to two nurses and 14 patients to one physician, above which there is an increase in ICU mortality. Those shifts with inadequate staffing resources, given the patients' needs, occurred mostly during weekends for nurses and at nights for physicians. In addition, higher risk of death was strongly influenced by heavy workload during shifts based on increased patient turnover and volume of LSPs performed by ICU teams.

Although some subsets of these parameters have been explored previously, the literature is scarce regarding the shift-by-shift analysis of both staffing and workload measures in a multicenter setting. Studies are traditionally based on fixed levels of staff (ie, ratios fixed a priori for periods of a few months) (26), instead of considering daily staff variations. This lack of granularity may explain why there is currently inconsistent association between medical staffing and patient outcome (2). In agreement with the guidelines of the Society of Critical Care Medicine for safe care, the present results clearly highlight a threshold effect regarding medical staff size relative to the number of patients and their needs. The present results also support previous observations, suggesting a potential relationship between ICU mortality and nurse staffing (2, 7, 10–13, 16, 20).

This study opens the way to an automated monitoring system. All types of data computed in the present work were collected routinely. Therefore, automating the process to provide a continuous follow-up of the adequacy of staffing levels and workload is possible. Such a monitoring tool would help manage staffing adequately and optimize patient flow. However, using routinely collected data to investigate preventable deaths caused by failures in ICU organization have clear limitations. In addition to excluding deaths with DFLST orders from our dataset, a solution would be to collect specific causes of death, such as "failure to rescue," which may reflect an unbalanced staffing level (1). In addition, we primarily used a combination of patient turnover and LSPs to assess work intensity at the team level. In the studied ICUs and in the majority of French ICUs, there is no consult team to take care of less-sick patients in ICUs. The same team is in charge of new admissions and other patients at the same time. So the observed workload is the sum of the patients in the ICU and new admissions.

TABLE 2. Characteristics of Shifts Without Any Death or With At Least One Death

	Shifts Without Death (n = 11,251)	Shifts With ≥ 1 Death (n = 415)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Patients-to-nurse ratios (%)				
< 1:1	290 (2.6)	5 (1.2)	1	1
1:1–1.5:1	2,748 (24.4)	91 (21.9)	1.6 (0.8–2.9)	1.9 (0.7–4.6)
1.5:1–2:1	5,143 (45.7)	181 (43.7)	1.7 (0.9–3.1)	2.0 (0.8–5.0)
2:1–2.5:1	2,461 (21.9)	103 (24.8)	1.8 (0.9–3.2)	2.3 (0.9–5.8)
> 2.5:1	609 (5.4)	35 (8.4%)	2.2 (1.2–4.3)	3.5 (1.3–9.1)[a]
Patients-to-physician ratios (%)				
< 8	8,144 (72.4)	256 (61.7)	1	1
8:1–10:1	1,391 (12.4)	59 (14.2)	1.0 (0.8–1.3)	0.9 (0.7–1.3)
10:1–14:1	1,408 (12.5)	74 (17.8)	1.0 (0.8–1.3)	1.1 (0.8–1.5)
> 14:1	308 (2.7)	26 (6.3)	1.5 (1.0–2.1)	2.0 (1.3–3.2)[a]
Residents-to-physicians ratio (SD)	0.27 (0.26)	0.26 (0.25)	0.7 (0.4–1.1)	0.9 (0.5–1.5)
Mean patient turnover (SD)[b]	6.8 (9.2)	7.8 (11)	2.3 (1.1–4.7)	5.6 (2.0–15.0)[c]
Mean number of life-sustaining procedure (SD)[d]	1.3 (0.4)	1.4 (0.4)	4.4 (3.5–5.4)	5.9 (4.3–7.9)[c]
Mean proportion of men (SD)	0.6 (0.1)	0.6 (0.1)	1.6 (0.9–2.8)	1.8 (0.8–3.8)
Mean proportion of surgical cases (SD)	0.6 (0.3)	0.6 (0.3)	0.6 (0.4–1.0)	0.5 (0.2–1.1)
Mean Simplified Acute Physiology Score II[e] (SD)	50 (11)	52 (11)	1.5 (1.4–1.7)	1.5 (1.3–1.7)[c]
Mean number of comorbidities (SD)[f]	2.2 (0.6)	2.3 (0.6)	1.1 (0.9–1.3)	0.9 (0.8–1.1)

RR = relative risk.
[a] $p < 0.01$.
[b] Number of admissions plus discharges (excluding death) over the census during the shift, in percentage.
[c] $p < 0.001$.
[d] Mean number of life-sustaining medical procedure (LSPs; Annex 1) per patient-day.
[e] Risk ratios for Simplified Acute Physiology Score (SAPS) II are computed for 10-point increase.
[f] Conditions extracted from the Elixhauser list of comorbidities (22).
Risk ratios correspond to a bivariate Poisson mixed model with random effect on ICU. Adjusted risk ratios and p values correspond to a multivariate Poisson mixed model with random effect on ICU. The multivariate model includes the following variables: patient-to-nurse, patient-to-physician, and residents-to-physicians ratios, patient turnover, number of LSP, proportion of men, proportion of surgical cases, SAPSII and number of comorbidities.

Representing the workload as a combination of LSPs, patient severity and turnover allowed us to take into account both patients present in the ICU and new admissions. Tracking the caregivers' well-being and how they are experiencing the burdens of daily activities may provide additional information (27). Furthermore, several nursing workload scores have been previously developed, such as the therapeutic intervention scoring system, the nursing activities score, or the nine equivalents of nursing manpower use score (28). Unfortunately, these metrics were not present in available databases.

In terms of generalizability, this study was performed over eight closed ICUs in four academic hospitals. Despite a limited sample size, we think that the findings can probably be generalized to the other French academic hospitals given that their organization does not vary much. Also, our analyses showed no influence of the number of residents per physician on patient mortality. Therefore, we can argue that our findings may also apply to nonacademic hospitals. Although any ICU with an organization similar to the ICUs from this study could benefit from the present results, it would be interesting to validate our findings although replication studies in other countries. The optimal P/P ratios may be different in the context of open ICUs, where the physician formally responsible for the patient is not the intensivist and physicians from outside of the ICU may participate in patient care. Another limitation to this study is that no adjustment was feasible regarding the specialty of ICU physicians (ie, intensivist, anesthesia, and mixed) that may have influenced patients' outcomes.

Representing a real picture of daily workload in the ICU, this study raises further unresolved questions. What are the exact conditions of excessive workload and insufficient staffing that lead to avoidable deaths in the ICU? Ideally, investigating shift-to-shift variations of caregivers staffing and patient turnover would allow identification of which caregiver is assigned to a given patient at any time in a particular ICU. Here, we provided this information at the unit level at each time period. The next step would be to introduce the linking of individual data between patients and caregivers, allowing for a dynamic

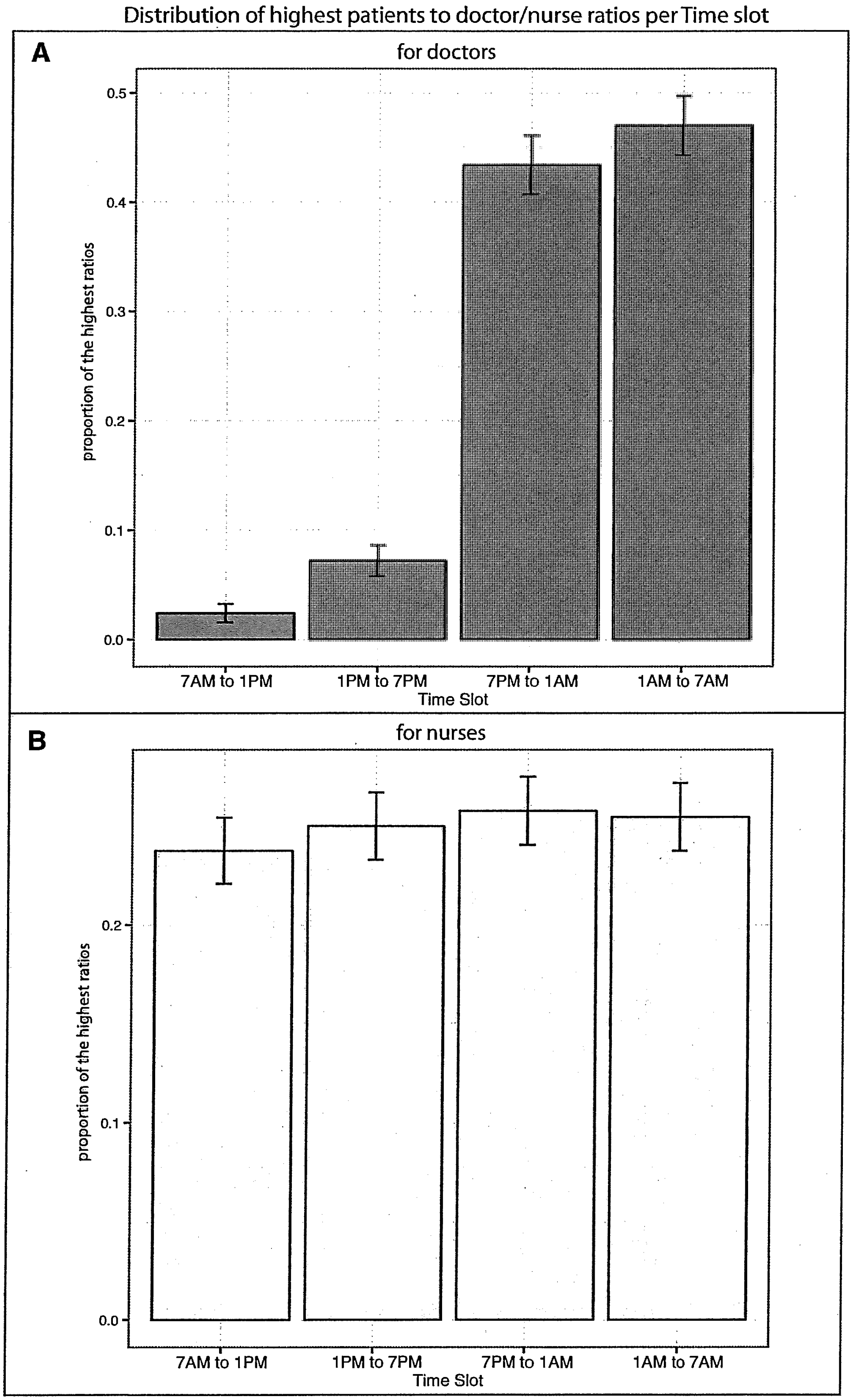

Figure 2. Distribution of highest ratios across shifts. Highest ratios correspond to > 2.5 patients per nurse and > 14 patients per physician.

analysis of their interactions (29, 30). Indeed, workload may not be uniformly distributed over time across different team members. For example, two patients assigned to the same caregiver may need urgent care, whereas other caregivers might simultaneously experience a lower workload. In this situation, it is likely that the latter helps the former. A solution to this issue was proposed in some ICUs. Teams dedicated to managing new ICU admissions have been implemented in a delimited ICU zone. The performance of such organizations, which aim to prevent ICU malfunction that results from excessive turnover, should be assessed. Furthermore, what are the determinants of clinical team performance, and how can we make efficient teams? Quantifying the patient-to-caregiver ratio in real time provides an overall view of the appropriate staffing level. A more accurate evaluation of the capability of a team to properly handle difficult situations represents the next step. Analysis of individual characteristics and interactions among team members should be considered because team composition and familiarity might influence its resilience to intense workload variations (31). Thus, high-performance teams would maintain high levels of quality when exposed to stressful situations, and teamwork skills may surpass the sum of individual talent. Staff experience, or the number of shifts involving the same colleagues, may reflect expertise and how well people communicate with each other through the acquisition of skills that allow for quick responses that can guarantee patient

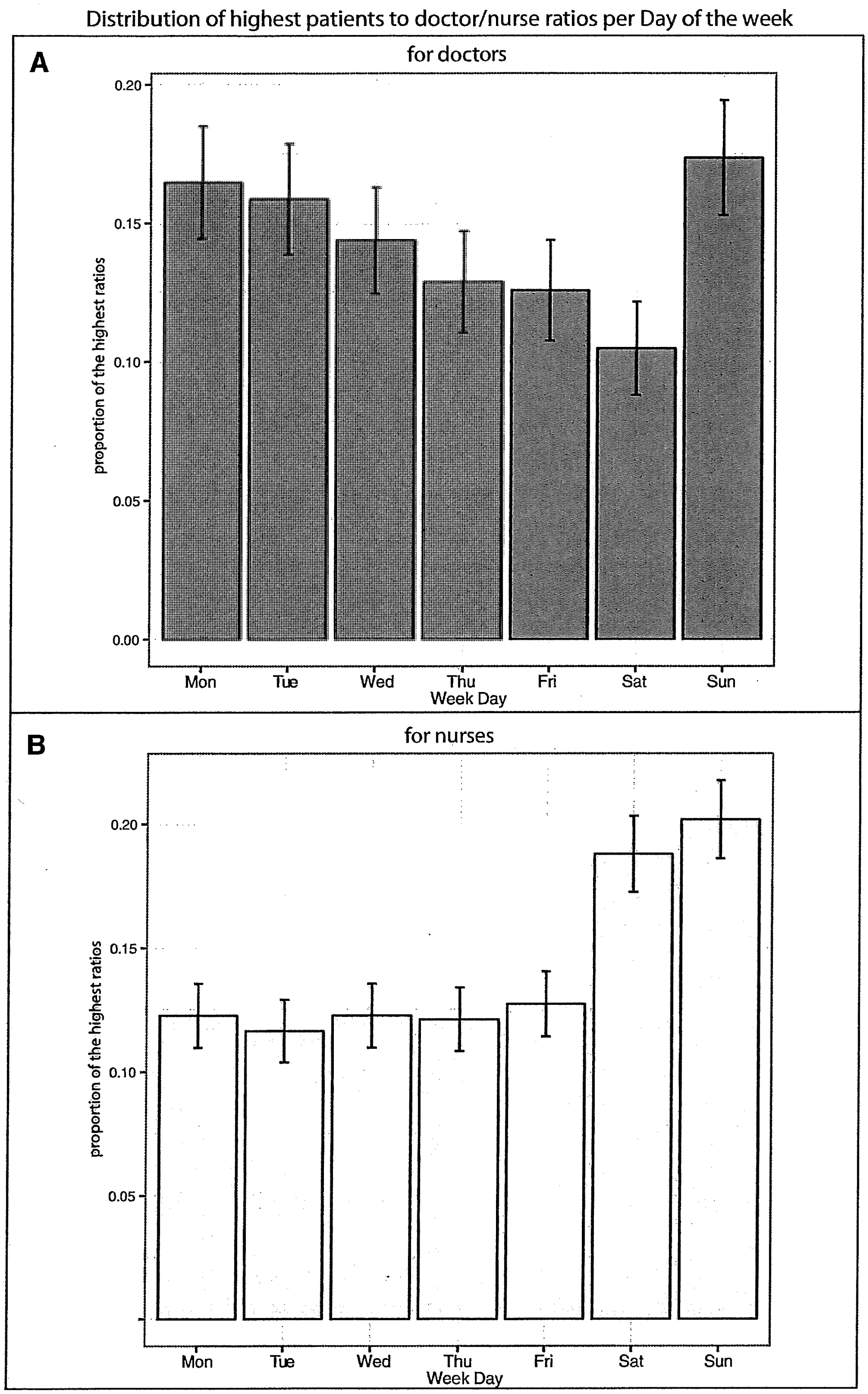

Figure 3. Distribution of highest ratios across days of the week. Highest ratios correspond to > 2.5 patients per nurse and > 14 patients per physician.

surgical settings (33). Team training might be useful to improve patient outcome in ICUs (34, 35).

This study proposes evidence-based ratios of patients per nurse and physician in the context of ICUs. Our findings support recommendations for adapting caregivers' resources to patients' needs in real time. Insufficient staffing above the observed maximum thresholds showed an increased risk of mortality. Particular attention should be paid to critical periods identified to be at risk of high patient-to-caregiver ratios (ie, on weekends for nurses and at night for physicians). Moreover, identification of patient turnover as an independent risk factor of mortality should lead to a thoughtful management of patient influx during a single shift. Delaying admissions during periods when teams are experiencing a heavy workload with unbalanced patients-to-caregivers ratios could prevent ICU disorganization. However, the heterogeneity staffing patterns in ICUs around the world cannot be overlooked: larger studies involving different countries will be needed to validate these findings. Because all data used in this study were routinely collected in hospital information systems, real-time monitoring of staffing levels and workload with dedicated alarms is feasible. Such monitoring of patient-to-caregiver ratios would help not only to have sufficient resources for guaranteeing patient safety when needed but also to avoid wasting in case of temporary overstaffing. Hence, continuous balancing between staffing resources and workload may increase care efficiency in ICUs.

safety (32). In the same manner, safety culture in the team may play a role in patient safety. Methods such as crew resource management imported from aviation were implemented in

Otherwise, a cost-effective solution would consist of smoothing activity and staff presence over time according to threshold recommendations.

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REF 13: HANCKNER ET AL

Do Faculty Intensivists Have Better Outcomes When Caring for Patients Directly in a Closed ICU versus Consulting in an Open ICU?

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Abstract

Background: Intensivists have been associated with decreased mortality in several studies, but in one major study, centers with intensivist-staffed units reported increased mortality compared with controls. We hypothesized that a closed unit, in which a unit-based intensivist directly provides and coordinates care on all cases, has improved mortality and utilization compared with an open unit, in which individual attendings and consultants provide care, while intensivists serve as supervising consultants. **Methods:** We undertook the retrospective study of outcomes in 2 intensive care units (ICUs)—a traditional open unit managed by faculty intensivists and a second closed unit overseen by the same faculty intensivists who coordinated the care on all patients in a large community hospital. **Primary Outcome:** In-hospital mortality. **Secondary Outcomes:** Hospital length of stay (LOS), ICU LOS, and relative costs of hospitalization. **Results:** From January 2006 to December 2007, we identified 2602 consecutive admissions to the 2 medical ICUs. Of all patients admitted to the closed and open units, 19.2% and 24.7%, respectively, did not survive ($P < 0.001$, adjusted for severity). Median hospital LOS was 10 days for the closed unit and 12 days for the open unit ($P < 0.001$). Median ICU LOS was 2.2 days for the closed unit and 2.4 days for the open unit ($P =$ NS). The unadjusted cost index for the open unit was 1.11 relative to the closed unit (1.0) ($P < 0.001$). However, after adjusting for disease severity, cost differences were not significantly different. **Conclusions:** We observed significant reductions in mortality and hospital LOS for patients initially admitted to a closed ICU versus an open unit. We did not observe a significant difference in ICU LOS or total cost after adjustment for severity.

Keywords: intensive care unit; staffing; closed unit; open unit; outcomes

Background

Several studies have reported improved outcomes in closed intensive care units (ICUs) or units staffed with dedicated intensivists in comparison with open ICU models.[1-8] In contrast, Levy et al[9] reported in Project IMPACT seemingly contrary results, in sharp contrast with the evidence summarized by the Committee on Manpower for Pulmonary and Critical Care Societies.[10]

In this study, we took advantage of a unique opportunity—the opening of an entire critical care tower—to study 2 units staffed with the same faculty intensivists, both of which meet Leapfrog criteria. Both shared physically present intensivists who were knowledgeable about ICU practice, as well as intensivist directors.[11,12] A critical element distinguished the 2 units: the open unit allowed multiple intensivists and even nonintensivists to coordinate plans on patients, and faculty intensivists served only "advisory, assistive, or consultative" roles. In the closed unit, assigned faculty intensivists were the sole physicians to coordinate team care on all patients and functioned as "captains of the ship" (Table 1). We report our findings on faculty intensivist physician staffing (IPS) under 2 different rules of engagement.

Methods

A retrospective review of all ICU admissions between January 2006 and December 2007 identified 2603 newly admitted adult medical patients in 2 units managed by the Pulmonary/Critical Care Division in an urban, 950-bed academic community hospital (Figure 1A). Intensive care unit patients initially admitted to another unit and later transferred were not included. Of these, 1211 patients were initially admitted to the closed unit and 1391 to the open unit, as defined by Pronovost et al.[3] In the closed unit, the intensivist is the patient's primary attending physician, while other physicians serve in consultative roles. In the open unit, the original primary attending continues to manage care and has the option of calling an intensivist as a consultant.

The primary outcome was in-hospital mortality. Secondary outcomes included hospital length of stay (LOS), ICU LOS, and total cost. Total costs included all facility costs of hospitalization. No professional fees or payer-specific patient charges were included. We also sought to

Table 1. Unit Characteristics. Both units shared identical faculty, fellows, and medical staff. In the open unit, any consultant or attending of record could write orders; the unit-based intensivist faculty member served in an "advisory, assistive, or consultative" role. In the closed unit, "critical care" management and orders were limited to the unit-based intensivist. In comparison with open units, in closed units, all care of patients was coordinated by unit-based faculty intensivists and unit-based attendings staffing the night and weekend hours. In the closed unit, pulmonary and cardiology specialists served in a consultative role.

Characteristic	Closed	Open
	Intensivists "direct all care"	**Intensivists "consult" and "supervise"**
Intensivist Physician Staffing		
Physical presence of faculty IPS	Yes	Yes
Intermittent presence of nonfaculty critical care consultants	Yes	Yes
Physicians knowledgeable about critical care	Yes	Yes
Coordination of Care by IPS	Yes	No
Role of IPS	"Captain of the ship"	"Advisory, assistive, or consultative"
Physician coordinating care on case	Unit-based IPS	Attending of record
Orders written by	Unit-based IPS	Any physician on case
Paid in-house attendings in ICU nights and weekends	Yes	No
Unit Management		
Teaching unit	Yes	Yes
Intensivist MD director	Yes	Yes
Critical care nurse manager	Yes	Yes
Call Coverage		
Fellow based in unit daytime	Yes	Yes
Fellow on call for unit nighttime	Yes	Yes
Fellow or attending rounding in-unit weekends	Yes	Yes
Admissions to ICU		
ED cases: emergency physicians coordinate care for first ~4 hours	Yes	Yes
Regular floor cases: RRT/house physician admit patients ≥ ~30 minutes	Yes	Yes
Physicians determine placement to open or closed unit	No	No
Centralized bed placement based on acuity and wait time	Yes	Yes
Use of a transfer center for lateral and higher level cases	Yes	Yes
Interfacility transfers pass through ED	Yes	Yes

Abbreviations: ED, emergency department; IPS, intensivist physician staffing; RRT, rapid response team.

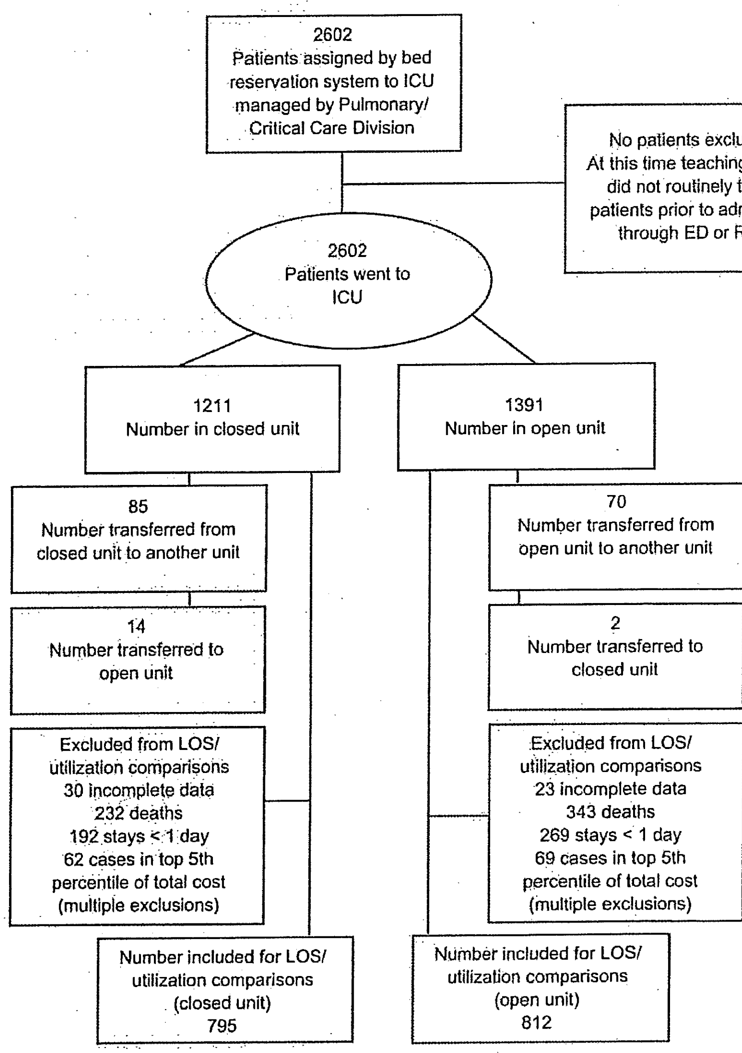
describe the distribution of deaths for patients admitted to the ICU (directly admitted from emergency department [ED] versus initial admission to floor ward) (Figure 1B).

Description of Units and Patient Assignment

The open unit consisted of a faculty member, 6 residents, and 1 fellow, who together made daily teaching rounds on 12 patients (Table 1). Faculty and fellows were also responsible for overall care of approximately 12.3% of cases assigned to them. The latter cases were largely unfunded and indigent. In the remaining cases, a voluntary, nonfaculty internist managed care with subspecialists but was only intermittently present in the ICU. During nights and weekends, resident-led teams (R2 or R3) took on-site admissions to the ICU, backed up by a critical care fellow and attending on call for the unit.

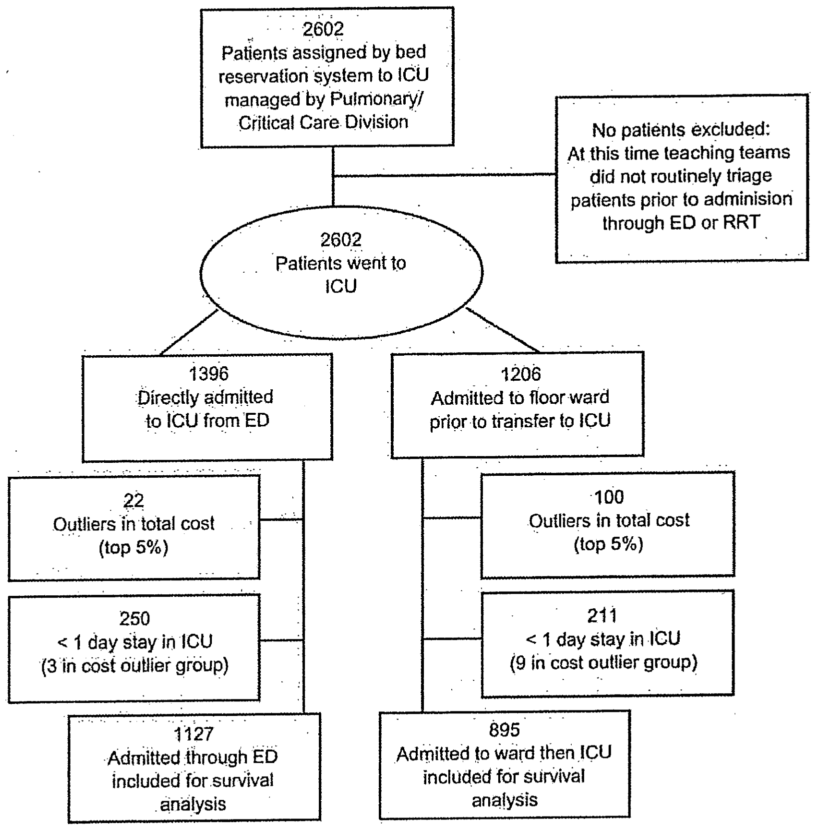
The closed unit consisted of a faculty member and 2 pulmonary/critical care fellows who together made daily teaching rounds on 12 patients. Faculty and fellows were responsible for triage and procedures in the unit, with the same procedural services independently available to the unit. Faculty and fellows were responsible for coordination of care and decisions on all 12 patients in the unit. Similar to the open unit, 12.8% of cases were originally assigned to faculty hospitalists prior to admission. The faculty of this unit took the predominant role in determination of goals of care for all patients in the unit. During nights and weekends, paid house attendings and intensivists took on-site admissions to the ICU.

Figure 1A. Controlled study based on assignment to closed or open ICU. For LOS, total costs, and cost breakdowns, after exclusion of deaths, analysis was done with and without outliers (≤ 1 day LOS and top 5th percentile in hospital LOS).



Abbreviations: ED, emergency department; ICU, intensive care unit; LOS, length of stay; RRT, rapid response teams.

Figure 1B. Controlled study based on assignment to closed or open ICU. For survival analysis, patients admitted from floor or directly from ED were analyzed separately after excluding outliers in the top 5th percentile of cost or cases that spent < 1 day in ICU. For survival, a modified intention to treat approach was applied based on the first ICU admission.



Abbreviations: ED, emergency department; ICU, intensive care unit; RRT, rapid response teams.

Assignment of cases to the units was made on a rotating basis by a bed-placement system that admitted medical patients to both units. While voluntary physicians rarely requested a particular ICU, few of these requests were accommodated due to capacity issues. Patients who needed to be transferred to the ICU were placed in the first available ICU bed. The ED directly admitted to the ICU without the intercession of the team (no "mandatory transfer") and also provided critical care services during the average 4 hours in the ED. Patients were analyzed according to the unit in which they were first admitted. The study was Institutional Review Board (IRB)-approved and an exemption to patient consent was obtained prior to analysis.

Statistical Analysis

Comparisons were made between open and closed units for each variable using the independent t-test, chi-square analysis, and analysis of variance (ANOVA) test. For LOS and total cost comparisons, Wilcoxon rank-sum tests were applied, as the variables were not normally distributed. Length of stay analyses were performed with and without LOS outliers: cases with ICU LOS ≤ 1 day or those patients in the top 5th percentile of LOS. All statistical analyses were performed using Statistical Analysis Software (version 9.1; SAS Institute Inc., Cary, NC).

Survival analysis was performed on the 2 populations based on source of admission. Kaplan–Meier curves for in-hospital mortality were stratified by ED admissions, ICU direct admissions, and floor-to-ICU transfers using the log-rank statistical method. While survival analysis was performed, the findings were coupled with an analysis of in-hospital mortality. Survival through a prolonged intensive course only to die in-hospital may be an unfavorable outcome.

Multiple logistic regression analysis was performed using in-hospital deaths as the dependent variable and several independent variables, including age, sex, race, ethnicity, illness severity, acuity, and activity. For illness severity, we included All Patient Refined Diagnosis Related Groups (3M™ APR-DRG) severity scores, Acute Physiology and Chronic Health Evaluation II (APACHE II) at 24 hours, and Simplified Acute Physiology Score II (SAPS II). For acuity and activity, we used the Quantitative Therapeutic Intervention Severity System-28 (QTISS-28) score. Days prior to intensive care, presence of a major surgical procedure, and presence of a hospitalist or privileged critical care physician were also analyzed. Factors also included time to readmission to ICU, readmission within 24 hours or 72 hours, and time in readmission unit (Tables 2, 3). A frequency table of patient mortality in the initial ICU and subsequently on the floor (or other unit) was constructed (Table 4).

Secondary Outcomes

Due to the distribution of data, LOS and ICU LOS were reported as medians, and the Wilcoxon rank-sum test was applied. Patients staying < 1 day and those in the top 5th percentile in hospital LOS were also excluded from analyses of LOS. Secondary outcomes included readmission to ICU and disposition following hospital stay. We also reported specialty consultation rates and relative hospitalization costs.

Costs

Because individual costs and charges are not generalizable from center to center, and due to the sensitive nature of this data, we reported costs as indices. In all cases, transformations divided individual case costs with median reference unit costs (indexed cost of case/median cost of closed unit). Severity-adjusted values are also reported in Table 4.

"Total cost" was defined as the sum of all patient care-related (direct) and non-patient care-related (indirect) costs as indices based on the median cost for the closed unit:

Total cost (open) = total cost (open)/median cost (closed).

Total cost (closed) = total cost (closed)/median cost (closed).

We reported "direct-variable" costs, defined as the costs associated with resource utilization (such as salaries and supplies), as indices based on median "direct-variable" costs of the closed unit. We also reported "direct-fixed" costs, defined as operational and academic costs not related to esource utilization but related to patient care.

Table 2. Severity Scores

A. 3M™ APR-DRG Severity Scores. Distribution of 3M™ APR-DRG severity scores by unit.

3M™ APR-DRG Severity	Closed	Open
No severity information	30 (2.5%)	23 (1.7%)
1	51 (4.2%)	59 (4.2%)
2	196 (16.2%)	185 (13.3%)
3	347 (28.7%)	371 (26.7%)
4	587 (48.5%)	753 (54.1%)

B. APACHE II Severity Scores. Distribution of APACHE II scores by quartile by unit.

APACHE II Score	Closed	Open
≤12	29.48%	25.59%
12–17	34.67%	33.03%
18–23	20.28%	20.87%
24+	15.57%	20.51%

Abbreviations: 3M™ APR-DRG, All Patient Refined Diagnosis Related Groups severity score; APACHE II, Acute Physiology and Chronic Health Evaluation II severity score at 24 hours after admission to intensive care unit.

Results

Mortality and Survival

Of all patients admitted to the closed and open units, 19.2% and 24.7%, respectively, did not survive ($P < 0.001$, adjusted for severity). Patients transferred from the floor had a 32% mortality in the open unit and a 22% mortality in the closed unit ($P = 0.003$). Patients admitted directly from the ED had 16.6% mortality for the closed unit and a 17% mortality for the open unit ($P = 0.91$).

Survival analyses were performed on the 2 populations based on source of admission. Kaplan–Meier curves were constructed for patients admitted directly from the ED ($P = 0.62$) and for those admitted from the floor ($P = 0.02$) (Figure 2). We observed significant differences between admissions from the ED and patients admitted from the floor wards, with long in-hospital stays (> 9 days) prior to ICU admission; after exclusion of those cases and after accounting for severity, there was still a significant contribution due to ICU allocation ($P = 0.04$).

Severity of Illness

We included 3 measures of severity: 3M™ APR-DRG, APACHE II, and SAPS II scores (Table 2). Chi-square test revealed a small but significant difference in proportions of patients by severity group ($P = 0.04$). The mean 3M™ APR-DRG severity class was 3.24 for the closed unit and 3.33 for the open unit ($P = 0.03$). Due to these small but statistically

Table 3. Patient Characteristics

Variables	Open Unit n = 1391		Closed Unit n = 1211		P Value
	Mean (± SD)	Frequency (%)	Mean (± SD)	Frequency (%)	
Age (years)	66.1 (18.4)		64.7 (18.6)		P = 0.06
Ethnicity Hispanic		173 (12)		107 (9)	P = 0.008
Race					
Caucasian		1043 (75)		911 (75)	
Black		239 (17)		215 (18)	
Asian-Pacific		66 (5)		45 (4)	
Native American		4 (0.3)		4 (0.3)	
Other		39 (3)		35 (3)	P = 0.77
Severity					
3M™ APR-DRG	3.3 (0.9)		3.2 (0.97)		P = 0.005
SAPS II	12.4 (6.5)		12.0 (6.5)		P = 0.08
APACHE II	15.8 (9)		14.7 (8.9)		P = 0.003
QTISS-28	25.2 (13.5)		24.2 (13.3)		P = 0.08
Physicians on Case					
Major surgical procedure		248 (18)		236 (20)	P = 0.26
Hospitalist on case		234 (17)		197 (16)	P = NS
Additional general critical care or pulmonary critical care physicians (aside from faculty intensivists)		117 (8)		117 (10)	P = 0.24
Consultants	2.5 (2.5)		2.7 (2.5)		P = 0.13
Faculty admissions		168 (12)		154 (13)	P = NS
Prior Location					
ED admission		708 (51)		688 (57)	
Transfer from floor		455 (33)		274 (23)	P = 0.003
Days on the Floor Prior to ICU	3.79 (9)		3.52 (11.8)		P = 0.51

Abbreviations: 3M™ APR-DRG, All Patient Refined Diagnosis Related Groups severity score; APACHE II, Acute Physiology and Chronic Health Evaluation II severity score at 24 hours after admission to intensive care unit; ED, emergency department; ICU, intensive care unit; NS, not significant; QTISS-28, Quantitative Therapeutic Intervention Scoring System-28; SAPS II, Simplified Acute Physiologic Score II.

different severity scores, study outcomes were analyzed by multiple regression analysis including these severity scores. One measure of acuity, QTISS-28, was not significantly different ($P = 0.11$). In multiple regression analysis, even after inclusion of severity indicators (3M™ APR-DRG, APACHE II, and SAPS II), a significant relationship between admission to an open unit and mortality persisted ($P < 0.001$).

Patients with the lowest and highest initial APACHE II quartiles (< 12 and 24+) on admission to ICU showed no significant differences in mortality. Patients presenting with intermediate initial APACHE II scores (13–17) showed the greatest difference in mortality (8.8% in closed unit vs 18.1% in open unit) with smaller, statistically insignificant differences observed for the most severely ill patients identified on ICU admission. Even though the closed unit admitted significantly fewer patients with APACHE II scores in one severity quartile (14–23), mortality was not significantly different for this quartile (31.4% for the closed unit and 28.7% for the open unit). All Patient Refined Diagnosis Related Groups severity scores, which are compiled after discharge or death, showed significant differences in outcome only in those with the highest severity scores (with 34.4% mortality in the open unit and 30% mortality in the closed unit).

An important covariate was the rate of intubation, which was significantly lower in the closed unit ($P < 0.05$). On the other hand, rates of tracheostomy and bronchoscopy, when included in multivariate analysis, did not affect the association of mortality and unit. Major surgical interventions, arterial or venous catheter placement, or endoscopic interventions (eg, GI, thoracic), also did not affect the association of mortality and type of ICU.

Table 4. Distribution of Deaths. Proportion of patients dying in the ICU or post-intensive care on the regular floors. For proportion of deaths occurring on the floor versus in the ICU ($P = 0.05$).

A

Mortality	Open Unit (n = 1391)	Closed Unit (n = 1211)
Total deaths	343 (24.7%)	232 (19.2%)
Deaths in ICU	194 (13.9%)	112 (9.2%)
Deaths post-ICU discharge	149 (10.7%)	120 (9.9 %)

B

Proportions of Deaths by Location	Open Unit (n = 343)	Closed Unit (n = 232)
Deaths in unit	56.6%	48.3%
Deaths post-ICU discharge	43.4%	51.7%

Abbreviation: ICU, intensive care unit.

Proportion of Deaths in the ICU and at Lower Level of Care

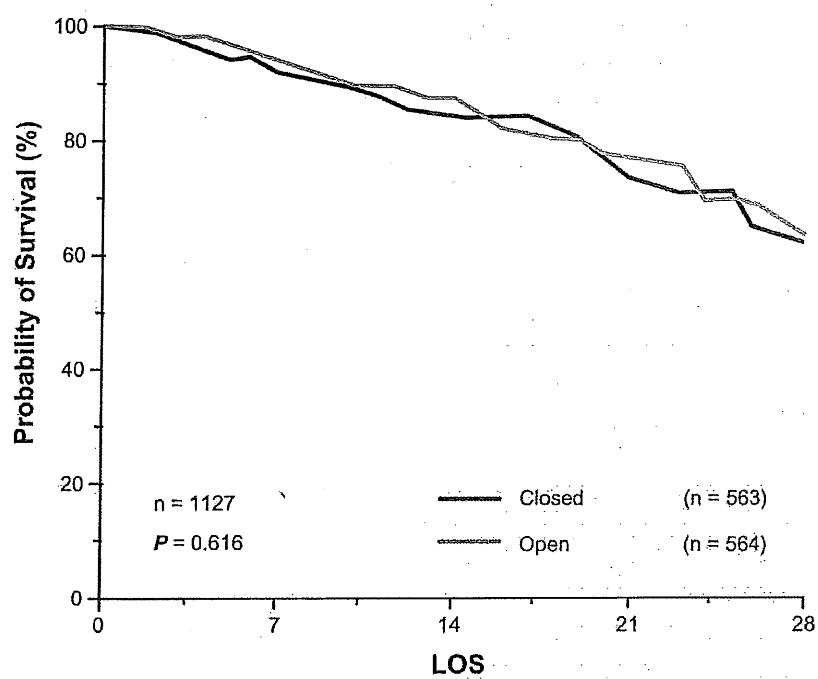
Among deaths in the ICU or following ICU transfer to the floor, there was a significant association between location of death and unit (open vs closed; $P = 0.05$). Of open unit patients, 13.9% died in the ICU, while 9.2% of closed unit patients died in the ICU (Table 4A, B). Multivariate analysis using the variable of admission at night and/or on the weekend, when staffing was more likely to involve trainees without attending IPS, did not affect these results (Table 1).

Hospital LOS and ICU LOS

Median LOS was 10 days (range, 1–512 days) for the closed and 12 days for the open unit (range, 1–307 days). In multiple regression, after inclusion of measures of severity (3M™ APR-DRG, APACHE II, and SAPS II), the association between unit and reduced stays remained ($P < 0.02$). Median ICU LOS was 2.2 days (range, 0.1–147.6) for the closed unit and 2.5 days (range, 0.1–76.3) for the open unit ($P = 0.38$).

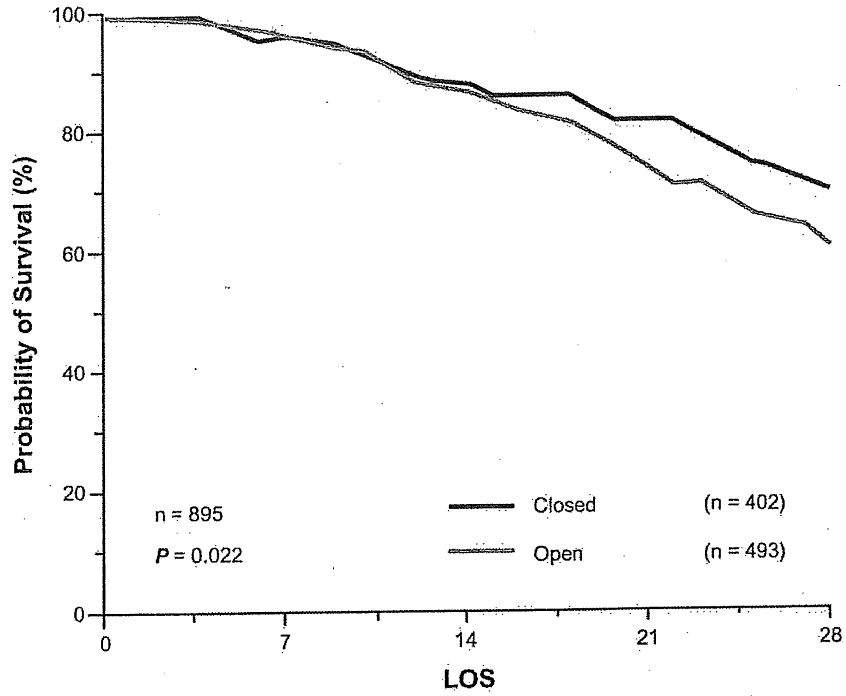
The proportion of patients in the ICUs with ≤ 1-day stays were significantly different between the open and closed ICUs ($P < 0.02$). In the long LOS outlier group, > 50% of cases had stays in multiple ICUs versus 7.5% in the remaining population. For these cases, days prior to ICU admission averaged > 20 days (in comparison with 2–3 for the rest of the population). Mortality and disposition were analyzed with and without these outlier cases.

Figure 2A. Kaplan–Meier curves of patients admitted from floor beds. Closed 100% intensivist-managed unit cases are indicated in black. Open unit with only a portion of cases attended by intensivists indicated in gray. All of these cases were admitted to a floor bed prior to transfer to the ICU. Exclusions for 1-day ICU LOS and high LOS outliers as described in methods.



Abbreviations: ED, emergency department; ICU, intensive care unit; LOS, length of stay.

Figure 2B. Kaplan-Meier curves of patients admitted from ED or from floor beds. Closed 100% intensivist-managed unit cases are indicated in black. Open unit with only a portion of cases attended by intensivists indicated in gray. Emergency department cases typically involved 4 hours of critical care prior to arrival in ICU. Exclusions for 1-day ICU LOS and high LOS outliers as described in methods.



Abbreviations: ED, emergency department; ICU, intensive care unit; LOS, length of stay.

Demographic Differences

Age, gender, and race did not appear to be significantly different in closed and open unit populations (Table 3). However, with higher proportions of Hispanic (Spanish-speaking) patients in the open unit (12.4% vs 8.9%; $P = 0.008$), ethnicity was included in multivariate analysis. No significant difference in outcomes was observed for this factor. Age and ethnicity were included in multiple regression analyses.

Costs and Utilization

Cases initially assigned to the open unit had a median total cost index of 1.11, compared with the closed unit, which, after adjustment for severity, was not statistically significant (Table 5). Direct-variable cost index was 1.13 for the open unit, relative to the closed ($P =$ NS). Significant differences were observed for blood bank, clinical laboratory, and pulmonary study indices but other areas such as pharmacy, imaging/radiology, inhalational therapy, and pathology services were not significantly different after adjustment for severity (Table 5). Outliers in LOS tended to spend more time on the floor prior to ICU admission (> 20 days), tended to be readmitted to other ICUs (> 50%), and tended to produce a large skew of the cost data. Even after excluding LOS outliers, the results showed for the ICU population insignificant differences in utilization, with the exception of blood products, pulmonary studies, and clinical laboratory.

Post-ICU and Post-Hospital Disposition

We observed significant differences in discharge disposition following hospitalization (Table 6). The disposition differences were largely due to significant differences in hospital mortality between the ICUs: 19.2% in the closed group and 24.7% in the open group ($P < 0.001$). Readmissions to the ICU were not significantly different, with 8.2% for the closed unit and 10.8% for the open unit. In both ICUs, there were low rates of return to ICU within 24 or 72 hours (1.2%–1.4%).

Role of Faculty Hospitalists

To investigate the relationship between faculty hospitalist involvement and outcomes (mortality, LOS, and cost), we performed multiple regression analysis with and without a closed unit, and with and without faculty hospitalists. In multiple regression analysis, presence of a hospitalist in the model was not associated with the mortality differences

Table 5. Costs. All costs are indexed based on the median closed unit cost. "Total costs" includes all costs associated with utilization and operations. "Direct cost" includes patient care elements only. "Variable" costs are related to utilization and "fixed" costs include academic and departmental costs not related to utilization. Cost "roll-ups" refer to all costs associated with the department or cost-center indicated.

Cost	Index	Index, Adjusted[a]	P Value[a]
	Open/Closed		
Total Cost	1.11	1.07	P = NS
– Total cost, excluding outliers	1.07	1.10	P = NS
Direct Cost			
– Direct cost—variable	1.13	1.11	P = NS
– Direct cost—fixed	1.11	1.09	P = NS
Cost Roll-ups[b]			
– Clinical laboratory	1.27	1.15	$P < 0.022$
– Pathology	1.29	1.09	P = NS
– Pulmonary studies	1.86	1.59	$P < 0.001$
– Blood bank	0.97	1.59	$P < 0.001$
– Inhalational therapy	1.86	1.22	P = NS
– Imaging and radiology	1.20	1.07	P = NS
– Pharmacy	1.25	1.12	P = NS

[a]Adjusted for 3M™ APR-DRG.
[b]Cost roll-ups excluding outliers.
Abbreviations: 3M™ APR-DRG, All Patient Refined Diagnosis Related Groups severity score; NS, not significant.

observed between units. However, faculty hospitalist cases, independent of open or closed unit, had lower LOS and cost for patients after controlling for payer type and severity of illness ($P = 0.003$). In Table 7, comparisons of faculty hospitalist versus other physicians' care outcomes are shown for the largest payer, Medicaid/Medical Assistance. Patients under the care of faculty intensivists and hospitalists throughout their hospital stay appeared to have the lowest LOS and total costs, controlling for payer type.

Discussion

This study reports significant differences in mortality and LOS of patients who received care under IPS in a closed unit versus patients who received care in an open unit, with the same physicians serving in a consultative capacity for most cases. In multivariate analysis, the mortality differences observed between the units could not be accounted for by the consultation of a specialist pulmonary/critical care physician, consulting general critical care physician, hospitalist on the case, or severity of disease differences between units.

The findings raise questions as to whether "salvageable" patients presenting with intermediate-severity disease are the main beneficiaries of closed ICU care, either due to early initiation of therapy, rapid transfer to the ICU, or appropriate high-acuity care. Due to the lack of statistically significant total cost differences (as well as several cost components), we cannot account for the difference in mortality based on overall intensity of resource utilization.

Closer analysis of the impact of the closed unit suggests that when all decisions for all unit patients are directly coordinated by the closed ICU team and directed by a faculty intensivist, there is a reduction in ICU mortality. In addition, as a proportion of all hospital deaths, a lower percentage of patients die in the ICU in the closed unit. In both ICUs, there were low rates of return to ICU within 24 or 72 hours, suggesting these transitions were safe. In short, the 24/7 faculty and IPS closed unit may have an important role in triaging patients able to survive ICU care and subsequent hospitalization.

At this facility, rapid response teams and house physicians were largely responsible for transfers of patients from the regular floor to ICU, thereby reducing one source of variation in care—time to ICU transfer, an important cause of bias. That was not the case for the ED cases, which routinely experienced delays of approximately 4 hours due to community-wide surges in demand. Any early differences in treatment between ICUs may have been mitigated by the standardized approaches of the ED team that provided critical care while awaiting patient ICU placement.

Several factors may account for the findings, including: 1) protocolized care in the first 4 hours (eg, sepsis protocols), 2) ICU teaching rounds and faculty/fellow involvement typically preceding voluntary "attending of record" involvement, 3) ED services, 4) timely specialty consultation, and 5) early palliation. Emergency department and teaching services appeared to operate efficiently in coordination with either unit. For patients under direct teaching faculty supervision, the service may even mitigate some of the increased utilization observed for patients not previously on teaching services on the regular floor. It is important to note that due to the pseudo-random assignment of patients to ICUs, a subtle difference in case assignment or patient flow may bias these results.

Questions Raised

The mortality reduction after patients have left the ICU raises questions about post-ICU effects and confounders. Faculty role in triage, early palliative care, clinical ethics involve-

Table 6. Hospital Disposition and ICU Disposition

	Open Unit	Closed Unit	*P* Value[a]
Hospital Disposition			$P = 0.04$ (including death)
Expired	24.7%	19.2%	$P < 0.001$
Lateral transfer	5.4%	5.0%	$P = NS$
Home or residential care	46.6%	53.2%	$P = NS$
Lower level of care (SNF or rehabilitation)	21.2%	20.3%	$P = NS$
ICU Disposition			
Readmit to ICU	10.8%	8.2%	$P = NS$
Readmissions to ICU within 24 hours	1.4%	1.2%	$P = NS$
Readmissions to ICU within 72 hours	3.5%	3.1%	$P = NS$
Readmit to same ICU	4.2%	3.1%	$P = NS$
To another ICU	17.7%	20.1%	$P = NS$
Percentage of outliers admitted to other units	49.3%	53.2%	$P = NS$
Transfer to another ICU	5.0%	7.0%	$P = 0.03$
Mortality of transferred patients	24.3%	20.0%	$P = NS$

[a]Adjusted for severity.
Abbreviations: ICU, intensive care unit; NS, not significant; SNF, skilled nursing facility.

ment, and inappropriate interventions at end of life may need to be explored in future studies. While the quantitative levels of staff and consultations were similar in both open and closed units, the impact of excessive or inappropriate consultations and interventions must be considered in the future.

The observed lower rate of intubations raises questions about possible respiratory-related confounders not captured by general severity scores, but the observation also raises questions about differences in approaches to ventilation between the open and closed units. The lack of a relationship between rates of tracheostomy or bronchoscopy and outcomes points to early decision-making as a key to understanding this finding. This is an important question for future study as appropriate and effective ventilation at end of life is an outcome increasingly seen as a quality benchmark.

Conclusion

In summary, we studied 2 teaching units with defined intensivist involvement: 1 closed unit with all cases coordinated by a faculty intensivist as "captain of the ship,"

Table 7. Faculty Hospitalist Cases versus Other Cases in Both Units. Comparisons of faculty service versus nonfaculty patients, controlling for payer type. Only faculty patients received all care by faculty members (faculty intensivists in ICU and faculty hospitalists post-ICU).

Same-Payer Comparison of Faculty and Non-faculty ICU Cases in Both Open and Closed ICUs (Medical/Medicaid)

Data	Faculty (n = 138)	Non-faculty (n = 167)	
LOS, median	10 (1–307)	12 (1–290)	$P = 0.04$
ICU LOS (initial unit)	2.3 (0.1–116)	2.1 (0.1–93)	$P = 0.51$
APACHE II[a]	13.3 ± SD 8.7	15.2 ± SD 9.7	$P = 0.09$
Costs, Indexed		**Non-faculty/Faculty**	
Total cost	1 (reference)	1.58	$P = 0.002$
Direct cost, variable	1 (reference)	1.61	$P = 0.003$
Disposition			
Readmission within 72 hours	8 (6%)	9 (6%)	$P = 0.88$
Mortality	18 (13%)	24 (14%)	$P = 0.74$

[a]APACHE II scores calculated at 24 hours. Mean scores and standard deviations reported. Even after accounting for differences in distribution of APACHE II and 3M™ APR-DRG severity scores, differences persisted.
Abbreviations: 3M™ APR-DRG, All Patient Refined Diagnosis Related Groups; APACHE II, Acute Physiology and Chronic Health Evaluation II; ICU, intensive care unit; LOS, length of stay; SD, standard deviation.

and a second open unit with the same faculty functioning in an advisory, assistive, or consultative role. Mortality and survival appear to be improved in the closed, faculty intensivist-coordinated care model, without statistically significant overall cost differences. Further research into this area is recommended.

Acknowledgments

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Conflict of Interest Statement

Dani Hackner, MD discloses conflicts of interest with Cedars-Sinai and Sage Publications. David D. Balfe, MD, Glenn D. Braunstein, MD, Ashraf Elsayegh, MD, Michael I. Lewis, MD, Zab Mosenifar, MD, and Chrisandra L. Shufelt, MD, MS disclose no conflicts of interest.

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Memorandum

DATE: **February 24, 2016**

TO: Nancy Farber, Chief Executive Officer

FROM: Ed Fayen, Sr. Associate Administrator

SUBJECT: Neuro Drills

A Neurosurgical drill is an instrument used to bore holes in bone for the attachment of surgical pins, plates, or screws and is critical to our surgeons who perform neurological surgeries. We have experienced several issues with our existing neuro-surgical power units during neuro-surgical cases. We currently have five drills and have been repairing them on a recurring basis since at least 2012. The life cycle for neuro drills is five years and our current equipment, aged seven years, has reached end of life. We need to bring in a new generation of neuro drills in order to eliminate the issue of reliability associated with the high volume of cases we do using the old Stryker power units and to decrease the downtime due to the necessity of frequent repairs.

We have negotiated a 37.22% discount with the vendor and will receive $25,000 in trade-in. The total cost for the purchase of five neuro drills $247,278.86. This item was not approved in the FY16 Capital Asset Budget.

In accordance with District Law, Policies and Procedures, I request that the Board of Directors authorize the Chief Executive Officer to proceed with the purchase of five Neurosurgical Drills in an amount not to exceed $247,278.86.

Washington Hospital Healthcare System
SINCE 1948

Memorandum

DATE: **February 19, 2016**

TO: Nancy Farber, Chief Executive Officer

FROM: Ed Fayen, Sr. Associate Administrator
John Lee, Chief Information Officer

SUBJECT: Increased Data Storage for Electronic Health Information Growth

We have multiple areas in which growth of data is requiring increases in data storage:

1. Our Epic Cache Database is growing. Since our initial Epic purchase in 2012 we have added new modules, established more information sharing with surrounding hospitals as well as initiated and developed an effective patient portal with MyChart. Flash drives will be added to our storage capacity to cover expected growth for the next 30-36 months.

2. The Sacramento Data Center has seen growth in our Clarity reporting database. This purchase of additional Electronic Health Information storage will cover expected growth for the next 24 months.

3. The Avamar and Data Domain backup solutions require additional storage to handle anticipated storage growth. We expect this new storage will cover expected growth for the next 24-30 months.

4. Similar storage is required at our Boulder, CO disaster recovery data center in order to allow for disaster recovery replication to continue.

The cost to purchase and add this storage is $220,468.34 and is part of the fiscal year 2016 IS capital budget. The project will take approximately two months to complete.

In accordance with District Law, Policies and Procedures, it is requested that the Board of Directors authorize the Chief Executive Officer to enter into the necessary contracts and proceed with the purchase of the hardware, software and implementation services, for a total amount not to exceed **$220,468.34**. This is an approved project in the 2016 Capital budget.

Memorandum

DATE: **February 19, 2016**

TO: Nancy Farber, Chief Executive Officer

FROM: Ed Fayen, Associate Administrator of Operations and Support
John Lee, Chief Information Officer

SUBJECT: Clinical Quality Metric Software

Currently manual data entry and manual data transfers between systems are required to generate Ongoing Professional Practice Evaluation (OPPE) reports at Washington Hospital. The hospital purchased the Statit system to replace manual data entry, data transformation, and report compiling between systems for the purpose of developing OPPE reports. The Statit Physician Profile and Review (Statit PPR) systems can improve the process of creating OPPE reports by taking physician-related data from many different systems/data sources and presenting the data as graphic indicators and profiles. The system also offers medical providers web-based access to their individual performance profiles.

This project will significantly improve the workflow of monitoring physician outcomes and allow physicians to monitor their own practice at any time. It also provides senior leadership with the ability to identify areas of strength and weakness and indicates ways to improve the quality of patient care and outcomes. Overall, the implementation of Statit OPPE will result in better patient care and improve overall hospital outcomes significantly.

The cost to implement Statit OPPE is $103,403.52 and this is part of the fiscal year 2016 IS capital budget. The project will take approximately six months to fully complete and will be performed using external labor.

In accordance with District Law, Policies and Procedures, it is requested that the Board of Directors authorize the Chief Executive Officer to enter into the necessary contracts and proceed with the purchase of implementation services, for a total amount not to exceed **$103,403.52**

Washington Hospital Healthcare System

SINCE 1948

Memorandum

DATE: **February 19, 2016**

TO: Nancy Farber, Chief Executive Officer

FROM: Ed Fayen, Sr. Associate Administrator
John Lee, Chief Information Officer

SUBJECT: Perinatal Clinic Electronic Health Record Build

In anticipation of the opening of a Perinatal Diagnostic Clinic in the District for high-risk mothers, the Information Services department is requesting funding to setup a new Hospital Outpatient Department (HOD) within our current Epic WeCare environment. UCSF Perinatologists will be practicing at the Clinic but work will be documented in WeCare.

The total budget requested includes time for analysis, build, validation, testing, instructional design and go live support. An additional equipment related request will be made through a separate memorandum. The cost to complete the Perinatal Clinic Epic Build is $149,460.00 and this is part of the larger New Clinic Build line item approved in the fiscal year 2016 capital budget. The build is expected to be completed within 7 months.

In accordance with District Law, Policies and Procedures, it is requested that the Board of Directors authorize the Chief Executive Officer to enter into the necessary contracts and proceed with the purchase of implementation services, for a total amount not to exceed **$149,460.00**

RESOLUTION NO. 1164

RESOLUTION OF THE BOARD OF DIRECTORS OF WASHINGTON TOWNSHIP HEALTH CARE DISTRICT AUTHORIZING CHIEF EXECUTIVE OFFICER TO ENTER INTO AGREEMENT WITH THE PRINCIPAL FINANCIAL GROUP REGARDING CERTAIN RETIREMENT BENEFITS

WHEREAS, the Washington Township Health Care District is a local health care district ("District") which owns and operates a general acute care hospital and provides essential healthcare services to the population residing within the District's political boundaries, including the cities of Fremont, Newark, Union City, parts of South Hayward and Sunol;

WHEREAS, the District maintains a pension program for employees and retirees pursuant to section 401(a) of the Internal Revenue Code ("Code"); and

WHEREAS, the District believes that diversifying the pension plan investments is prudent to enhance the long-term viability of the pension program; and

WHEREAS, the District previously authorized the creation of a new trust arrangement that complies with the requirements of Code section 401(a) (the "Trust"); and

WHEREAS, the Board previously authorized the Chief Executive Officer to investigate different options regarding the administration of and investments within the Trust; and

WHEREAS, the Chief Executive Officer has determined, based on advice from the District's pension consultants, that a group of 215 retirees must remain with the Principal Financial Group as the Principal Financial Group has issued insurance certificates guaranteeing their retirement benefits; and

WHEREAS, the Chief Executive Officer has determined, based on advice from the District's pension consultants, that the District should leave an amount on deposit with the Principal Financial Group in an amount required to fund the retirement benefits for the 215 retirees with the understanding that as such time as there are no longer any benefits to be paid, the Principal Financial Group will rebate any remaining funds to the District;

NOW THEREFORE, be it resolved that:

1. The Chief Executive Officer is hereby authorized, on behalf of the District, to enter into an agreement with the Principal Financial Group for the purposes set forth in this Resolution.

2. The Chief Executive Officer is hereby authorized to take any and all actions necessary to execute any and all instruments and do any and all things deemed by her to be necessary, or desirable, to carry out the intent and purposes of the foregoing resolution.

Passed and adopted by the Board of Directors of the Washington Township Health Care District this 9th day of March, 2016 by the following vote:

AYES:

NOES:

ABSENT:

______________________________	______________________________
MICHAEL J. WALLACE	PATRICIA DANIELSON, RHIT
President, Board of Directors	Secretary, Board of Directors
Washington Township Health Care District	Washington Township Health Care District

Washington Hospital
Healthcare System

WASHINGTON HOSPITAL

MONTHLY OPERATING REPORT

January 2016

Washington Hospital Healthcare System

WASHINGTON HOSPITAL
INDEX TO BOARD FINANCIAL STATEMENTS
January 2016

Washington Hospital Healthcare System
SINCE 1948

Memorandum

DATE: March 4, 2016

TO: Board of Directors

FROM: Nancy Farber

SUBJECT: Washington Hospital – January 2016 Operating & Financial Activity

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SUMMARY OF OPERATIONS – (Blue Schedules)

1. **Utilization – Schedule Board 3**

ACUTE INPATIENT:	January Actual	Budget	Current 12 Month Avg.
Average Daily Census	182.5	176.5	160.5
# of Admissions	1,098	1,177	1,006
Patient Days	5,656	5,471	4,879
Discharge ALOS	5.08	4.65	4.77

OUTPATIENT:	January Actual	Budget	Current 12 Month Avg.
OP Visits	6,752	7,772	7,290
ER Visits	4,663	4,766	4,401
Observation Equivalent Days – OP	231	313	255

Comparison of January acute inpatient statistics to those of the budget showed a lower level of admissions and a higher level of patient days. The average length of stay (ALOS) based on discharged days was above budget. Outpatient visits were lower than budget. Emergency Room visits were below budget for the month.

2. **Staffing – Schedule Board 3**

Total paid FTEs were 86.9 below budget. Total productive FTEs for January were 1,176.3, 120.0 below the budgeted level of 1,296.3. Nonproductive FTEs were 33.1 above budget. Productive FTEs per adjusted occupied bed were 4.89, 0.53 below the budgeted level of 5.42. Total FTEs per adjusted occupied bed were 5.88, 0.39 below the budgeted level of 6.27.

3. **Income - Schedule Board 1**

For the month of January the Hospital realized a gain of $2,246,000 from operations.

Total Gross Patient Service Revenue of $180,775,000 for January was 1.2% below budget.

Deductions from Revenue of $140,242,000 represented 77.58% of Total Gross Patient Service Revenue. This percentage is above the budgeted amount of 77.08%.

Total Operating Revenue of $41,190,000 was $1,153,000 (2.7%) below the budget.

Total Operating Expense of $38,944,000 was $657,000 (1.7%) below the budgeted amount.

The Total Non-Operating Gain of $2,801,000 for the month of January includes an unrealized gain on investments of $1,212,000 and property tax revenue of $1,365,000. This property tax revenue will be used to pay the debt service for the general obligation bonds.

The Total Net Gain for January was $5,047,000, which was $622,000 more than the budgeted gain of $4,425,000.

The Total Net Gain for January using FASB accounting principles, in which the unrealized gain on investments and property tax revenues are removed from the non-operating income and expense, was $2,470,000 compared to a budgeted gain of $3,061,000.

4. **Balance Sheet – Schedule Board 2**

Assets Limited As To Use decreased $13,326,000 in January. This change was due to the payment of interest due on General Obligation and Revenue Bonds.

There were no other noteworthy changes in assets and liabilities when compared to the December 2015.

NANCY FARBER
Chief Executive Officer

NF/CH:cd

Washington Hospital Healthcare System

WASHINGTON HOSPITAL
STATEMENT OF REVENUES AND EXPENSES
January 2016
GASB FORMAT
(In thousands)

JANUARY						YEAR TO DATE			
ACTUAL	BUDGET	FAV (UNFAV) VAR	% VAR.			ACTUAL	BUDGET	FAV (UNFAV) VAR	% VAR.
				1	OPERATING REVENUE				
$ 137,281	$ 134,954	$ 2,327	1.7%	2	INPATIENT REVENUE	$ 866,592	$ 858,838	$ 7,754	0.9%
43,494	47,927	(4,433)	-9.2%	3	OUTPATIENT REVENUE	310,998	319,379	(8,381)	-2.6%
180,775	**182,881**	**(2,106)**	-1.2%	4	**TOTAL PATIENT REVENUE**	**1,177,590**	**1,178,217**	**(627)**	-0.1%
(140,242)	**(140,962)**	**720**	0.5%	5	**CONTRACTUAL ALLOWANCES**	**(904,741)**	**(906,547)**	**1,806**	0.2%
77.58%	**77.08%**			6	**CONTRACTUAL AS % OF REVENUE**	**76.83%**	**76.94%**		
40,533	**41,919**	**(1,386)**	-3.3%	7	**NET PATIENT REVENUE**	**272,849**	**271,670**	**1,179**	0.4%
657	424	233	55.0%	8	OTHER OPERATING INCOME	1,777	1,472	305	20.7%
41,190	**42,343**	**(1,153)**	-2.7%	9	**TOTAL OPERATING REVENUE**	**274,626**	**273,142**	**1,484**	0.5%
				10	OPERATING EXPENSES				
15,309	15,806	497	3.1%	11	SALARIES & WAGES	101,889	101,566	(323)	-0.3%
5,718	5,720	2	0.0%	12	EMPLOYEE BENEFITS	38,753	39,328	575	1.5%
4,086	4,365	279	6.4%	13	SUPPLIES	29,900	29,317	(583)	-2.0%
4,794	5,033	239	4.7%	14	PURCHASED SERVICES & PROF FEES	34,406	34,938	532	1.5%
1,292	1,458	166	11.4%	15	INSURANCE, UTILITIES & OTHER	9,311	10,047	736	7.3%
4,156	3,692	(464)	-12.6%	16	PROVISION FOR DOUBTFUL ACCOUNTS	24,937	24,245	(692)	-2.9%
2,762	2,716	(46)	-1.7%	17	DEPRECIATION	19,055	18,958	(97)	-0.5%
827	811	(16)	-2.0%	18	INTEREST EXPENSE	5,771	5,796	25	0.4%
38,944	**39,601**	**657**	1.7%	19	**TOTAL OPERATING EXPENSE**	**264,022**	**264,195**	**173**	0.1%
2,246	**2,742**	**(496)**	-18.1%	20	**OPERATING INCOME (LOSS)**	**10,604**	**8,947**	**1,657**	18.5%
5.45%	**6.48%**			21	**OPERATING INCOME MARGIN %**	**3.86%**	**3.28%**		
				22	NON-OPERATING INCOME & (EXPENSE)				
224	241	(17)	-7.1%	23	INVESTMENT INCOME	1,618	1,558	60	3.9%
(62)	0	(62)	0.0%	24	REALIZED GAIN/(LOSS) ON INVESTMENTS	(100)	0	(100)	0.0%
62	78	(16)	-20.5%	25	RENTAL INCOME, NET	510	543	(33)	-6.1%
0	0	0	0.0%	26	OTHER NON-OPERATING, NET	(1,233)	(966)	(267)	-27.6%
1,365	1,364	1	0.1%	27	PROPERTY TAX REVENUE	8,969	8,968	1	0.0%
1,212	0	1,212	0.0%	28	UNREALIZED GAIN/(LOSS) ON INVESTMENTS	12	0	12	0.0%
2,801	**1,683**	**1,118**	66.4%	29	**TOTAL NON-OPERATING INCOME & EXPENSE**	**9,776**	**10,103**	**(327)**	-3.2%
$ 5,047	**$ 4,425**	**$ 622**	14.1%	30	**NET INCOME (LOSS)**	**$ 20,380**	**$ 19,050**	**$ 1,330**	7.0%
12.25%	**10.45%**			31	**NET INCOME MARGIN %**	**7.42%**	**6.97%**		
$ 2,470	**$ 3,061**	**$ (591)**	-19.3%	32	**NET INCOME (LOSS) USING FASB PRINCIPLES****	**$ 11,399**	**$ 10,082**	**$ 1,317**	13.1%
6.00%	**7.23%**				**NET INCOME MARGIN %**	**4.15%**	**3.69%**		

**NET INCOME (FASB FORMAT) EXCLUDES PROPERTY TAX INCOME AND UNREALIZED GAIN(LOSS) ON INVESTMENTS

Washington Hospital Healthcare System

WASHINGTON HOSPITAL
BALANCE SHEET
January 2016
(In thousands)

	ASSETS AND DEFERRED OUTFLOWS	JANUARY 2016	AUDITED JUNE 2015
	CURRENT ASSETS		
1	CASH & CASH EQUIVALENTS	$ 25,078	$ 19,275
2	ACCOUNTS REC NET OF ALLOWANCES	67,970	61,503
3	OTHER CURRENT ASSETS	7,358	6,713
4	TOTAL CURRENT ASSETS	100,406	87,491
	ASSETS LIMITED AS TO USE		
6	BOARD DESIGNATED FOR CAPITAL AND OTHER	185,334	184,164
7	GENERAL OBLIGATION BOND FUNDS	220,123	121,657
8	REVENUE BOND FUNDS	10,431	10,390
9	BOND DEBT SERVICE FUNDS	14,540	21,349
10	OTHER ASSETS LIMITED AS TO USE	15,441	15,112
11	**TOTAL ASSETS LIMITED AS TO USE**	445,869	352,672
13	**OTHER ASSETS**	133,172	122,848
14	**NET PROPERTY, PLANT & EQUIPMENT**	446,099	416,245
15	**TOTAL ASSETS**	**$ 1,125,546**	**$ 979,256**
16	**DEFERRED OUTFLOWS**	15,996	24,472
17	**TOTAL ASSETS AND DEFERRED OUTFLOWS**	**$ 1,141,542**	**$ 1,003,728**

	LIABILITIES, NET POSITION AND DEFERRED INFLOWS	JANUARY 2016	AUDITED JUNE 2015
	CURRENT LIABILITIES		
1	CURRENT MATURITIES OF L/T OBLIG	$ 6,164	$ 5,995
2	ACCOUNTS PAYABLE	20,896	28,024
3	OTHER ACCRUED LIABILITIES	55,016	49,107
4	INTEREST	6,993	9,872
5	TOTAL CURRENT LIABILITIES	89,069	92,998
	LONG-TERM DEBT OBLIGATIONS		
6	REVENUE BONDS AND OTHER	204,168	208,626
7	GENERAL OBLIGATION BONDS	343,192	197,346
	OTHER LIABILITIES		
10	NET PENSION LIABILITY	47,003	66,440
11	WORKERS' COMP	9,075	8,609
12	SUPPLEMENTAL MEDICAL RETIREMENT	38,257	36,523
14	**NET POSITION**	402,367	381,987
15	**TOTAL LIABILITIES AND NET POSITION**	**$ 1,133,131**	**$ 992,529**
16	**DEFERRED INFLOWS**	8,411	11,199
17	**TOTAL LIABILITIES, NET POSITION AND DEFERRED INFLOWS**	**$ 1,141,542**	**$ 1,003,728**

Washington Hospital Healthcare System

WASHINGTON HOSPITAL
OPERATING INDICATORS
January 2016

12 MONTH AVERAGE	JANUARY ACTUAL	JANUARY BUDGET	JANUARY FAV (UNFAV) VAR	JANUARY % VAR.			YEAR TO DATE ACTUAL	YEAR TO DATE BUDGET	YEAR TO DATE FAV (UNFAV) VAR	YEAR TO DATE % VAR.
						PATIENTS IN HOSPITAL				
160.5	182.5	176.5	6.0	3%	1	ADULT & PEDS AVERAGE DAILY CENSUS	155.5	156.1	(0.6)	0%
8.4	7.5	10.1	(2.6)	-26%	2	OUTPT OBSERVATION AVERAGE DAILY CENSUS	8.0	8.6	(0.6)	-7%
10.5	11.0	11.0	-	0%	3	WELLBORN NURSERY AVERAGE DAILY CENSUS	10.7	10.8	(0.1)	-1%
179.4	201.0	197.6	3.4	2%	4	TOTAL	174.2	175.5	(1.3)	-1%
3.9	3.6	3.4	0.2	6%	5	SPECIAL CARE NURSERY AVERAGE DAILY CENSUS *	3.7	3.4	0.3	9%
4,879	5,656	5,471	185	3%	6	ADULT & PEDS PATIENT DAYS	33,442	33,554	(112)	0%
1,006	1,098	1,177	(79)	-7%	7	ADMISSIONS-ADULTS & PEDS	6,991	7,261	(270)	-4%
4.77	5.08	4.65	0.43	9%	8	AVERAGE LENGTH OF STAY-ADULTS & PEDS	4.69	4.61	0.08	2%
						OTHER KEY UTILIZATION STATISTICS				
1.517	1.548	1.503	0.045	3%	9	OVERALL CASE MIX INDEX (CMI)	1.523	1.503	0.020	1%
						SURGICAL CASES				
131	133	117	16	14%	10	JOINT REPLACEMENT CASES	934	787	147	19%
24	19	25	(6)	-24%	11	NEURO SURGICAL CASES	166	191	(25)	-13%
9	9	14	(5)	-36%	12	CARDIAC SURGICAL CASES	53	75	(22)	-29%
40	48	42	6	14%	13	MINIMALLY INVASIVE CASES	300	290	10	3%
394	359	359	-	0%	14	TOTAL CASES	2,848	2,466	382	15%
478	354	420	(66)	-16%	15	TOTAL CATH LAB PROCEDURES	2,574	3,000	(426)	-14%
151	147	161	(14)	-9%	16	DELIVERIES	1,081	1,085	(4)	0%
7,290	6,752	7,772	(1,020)	-13%	17	OUTPATIENT VISITS	49,814	50,912	(1,098)	-2%
4,401	4,663	4,766	(103)	-2%	18	EMERGENCY VISITS	30,178	31,584	(1,406)	-4%
						LABOR INDICATORS				
1,195.8	1,176.3	1,296.3	120.0	9%	19	PRODUCTIVE FTE'S	1,198.0	1,210.4	12.4	1%
173.6	236.4	203.3	(33.1)	-16%	20	NON PRODUCTIVE FTE'S	183.5	186.0	2.5	1%
1,369.4	1,412.7	1,499.6	86.9	6%	21	TOTAL FTE'S	1,381.5	1,396.4	14.9	1%
5.52	4.89	5.42	0.53	10%	22	PRODUCTIVE FTE/ADJ. OCCUPIED BED	5.67	5.65	(0.02)	0%
6.32	5.88	6.27	0.39	6%	23	TOTAL FTE/ADJ. OCCUPIED BED	6.54	6.52	(0.02)	0%

* included in Adult and Peds Average Daily Census