

# Improved Medical Decision Support Using the Analytic Hierarchy Process (AHP)

*Creating new Tools for Clinical Engineers,  
Health Systems Engineers, Clinicians, Insurers, and  
Administrators*

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Decision Sciences Institute Annual Conference  
San Diego, CA -- November 25, 2002

# Bio: Elliot Sloane, Ph.D.

*Dual Citizen of Clinical Engineering and Information Systems Worlds!*

- 27 Years of Clinical Engineering and Information Technology Expertise
  - Vice President, ECRI – 15 years (CIO, COO)
  - Vice President, MEDIQ/PRN – 10 Years (COO, CTO)
  - Assistant Professor of Decision and Information Technologies, Villanova University – since 2000
- Immediate Past President, American College of Clinical Engineering ([www.ACCEnet.org](http://www.ACCEnet.org))

# Purpose of our research

Focusing on bringing DSS application to healthcare

- Improve patient outcomes
- Improve physician/provider efficiency
- Improve technology selection and management

# About the Current Healthcare Environment

- Ongoing major economic challenges created by aging population, very high expectations, reimbursement limitations, and liability pressures
  - Fewer care givers, more patients, less money..

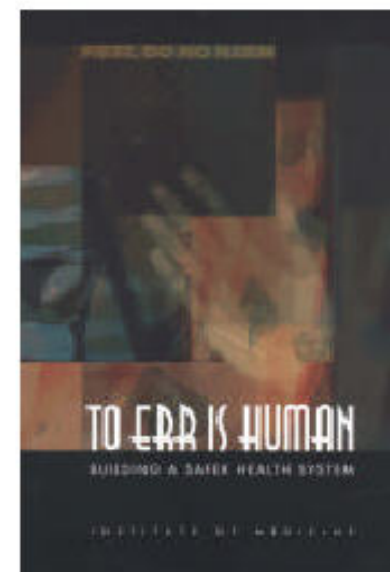
November 1999

# INSTITUTE OF MEDICINE

*Shaping the Future for Health*

## **TO ERR IS HUMAN: BUILDING A SAFER HEALTH SYSTEM**

**H**health care in the United States is not as safe as it should be--and can be. At least 44,000 people, and perhaps as many as 98,000 people, die in hospitals each year as a result of medical errors that could have been prevented, according to estimates from two major studies. Even using the lower estimate, preventable medical errors in hospitals exceed attributable deaths to such feared threats as motor-vehicle wrecks, breast cancer, and AIDS.



# New Healthcare Environment Factors

- ePortals and direct-to-consumer advertising for drugs and procedures are increasing patients awareness, expectations
  - This is driving demand and consumption of services, as well as litigation!
- The HIPAA law will have major ramifications my mid-decade

# DSS Application Needs in Healthcare Include the Following

- Clinical Decision Support
  - What procedures, drugs to use
- Patient Decision Support
  - Which technologies or providers to select
- Management/Administration Decision Support
  - Selection of healthcare technologies and drug formularies given limited reimbursement
  - Selection of computer systems in healthcare
- Insurance/Reimbursement Decision Support
  - Trade-offs and imposed limitations on caregivers, patients, families...

# Why we chose to use the Analytic Hierarchy Process (AHP): A brief introduction

- AHP is an *analytic* methodology used to prioritize: a) Criteria, and then b) Alternatives, when multiple criteria and alternatives must be considered
- AHP structures a decision problem as a *hierarchy*, or structured set of integrated levels or stages, of a decision *process*

AHP is supported by software such as Expert Choice 2000, which will be shown shortly

If you want to try this software, it is available with a new textbook:

DECISION TECHNOLOGY Modeling,  
Software, and Applications

by Liberatore and Nydick

J Wiley, ISBN 0-471-41712-2

October, 2002

*The book includes EXPERT CHOICE 2000 (AHP), Microsoft Project 2002, and additional DSS training software!*

# Our AHP Case Studies

- Healthcare Technology Assessments
  - New Neonatal Ventilator for a Women's Hospital
- Patient Decision Aid
  - Prostate Cancer Selection
- Eliminating a Patient Safety Problem
  - Selecting an IV infusion pump to prevent deaths
- Surgeon's Colorectal Patient Screening Aid
  - Identifying patients who will benefit from laparoscopic surgery (and those who won't)
- Physician practice management computer system selection
  - Selecting best alternative that meets legal and operational goals

# Case Study: Using AHP to Select Neonatal Ventilators for Woman's Health Facility

Matthew Liberatore

Robert Nydick

Elliot Sloane

Wenhong Luo

Q B. Chung

# New Women's Medical Facility

- Part of one of the largest independent hospital system in north suburban Philadelphia area
  - 500+ Bed Community Teaching Hospital
  - Growing, successful facility since 1914
- Thriving Obstetrics Program
  - Innovative Birthing Unit and Residency Teaching Program
- Thriving In-Vitro Fertilization (IVF) Program
  - Contributing to growing pre-term neonates, and "high risk" pregnancies with older women

# “NICU”

## Neonatal Intensive Care Unit

- State of the art, 24 bed unit
  - Incubators and Bassinettes
- Quiet and organized
  - Designed to limit additional stress to critical, fragile neonates and their families
- Filled to capacity! Last year 4400 births in the DR, 425 admissions to the NICU
- Includes transfers from area hospitals

# Future New Women's Health Hospital

- To be built in 2-3 years in the block north of present campus
- Specializing in all women's health services, including ob/gyn services
- The growing IVF program, and continued community service expansion, is likely to require expanded NICU support
  - New neonatal ventilators are likely to be needed

# Contemporary Neonatal Ventilator Requirements

- **Very precise control of small breaths, down to 100 ml levels**
  - Small, fragile lungs cannot withstand over-distension
- **Relatively high breath frequency, far above adult levels (100 bpm)**
- **Trigger sensitivities must be very low**
  - Neonates must not struggle to initiate each breath; the metabolic load may be fatal!

# A ventilator trade-off example:

- Choose full-range (neonates to obese adults), high end ventilators
  - Very expensive and complex
  - Some users state that a hospital may be able to share between adults and neonates
    - BUT, sharing does not meet THIS hospital's infection control requirements, so the higher cost of such units cannot be shared with adult ICU departments
- Or choose specialized neonatal ventilators, that can only be used in NICU, but cost 40-50% less than full-range ventilators and are simpler to use

# Another trade-off example:

Some neonatal ventilators can only be used with specific humidification systems

- Such systems may be needed to control moisture in the breathing tubes to the patient
  - Excessive moisture and cooling causes condensation of water; condensed water can drown neonate, and/or allow fungus and bacteria to grow
- Each humidification system has pros, cons, and differing life cycle costs to consider

# Analytical Hierarchy Process for Neonatal Ventilator Selection

- AHP Ratings Approach was used
  - Assigned rating categories for each criteria
    - e.g., Ventilator footprint: Small, medium, or large
  - Weighed the relative importance of each criteria against every other criteria in it's peer-group
    - e.g., "Footprint is 3 times more important than weight" or "Ease of use is 5 times more important than flexibility"
  - Assigned the value of each rating category alternative
    - e.g., "very easy to use" is 10 times more valuable than a "very difficult to use" alternative, but only 3 times more valuable than a "slightly difficult to use" alternative.)

# Status

- Accepted for publication C & OR 2003

# Lessons learned from the ventilator case...

- Creating the hierarchy and detailing the criteria and ranking stimulated clearer thinking and increased communication
  - It takes more time than just a casual chat!
    - Some criteria “fall out” as trivial, theoretical, or useless in the light of more careful consideration.
  - It yields a more realistic and complete picture of the situation
  - It provides a tool that allows measuring the impact of trade-offs of actual ventilators

# Case Study: Decision Support System for Men Considering Prostate Cancer Early Detection

Matthew J. Liberatore, Villanova University

Robert L. Nydick, Villanova University

Ronald Myers, Thomas Jefferson University

# The Problem

- 198,100 new cases of prostate cancer
  - 31,500 deaths from prostate cancer
- High risk groups include African American men and men with a family history of prostate cancer
- Men with asymptomatic prostate cancer usually diagnosed as a result of a screening exam that includes
  - digital rectal exam (DRE)
  - blood test for prostate specific antigen (PSA)

# The Controversy

- Pros of screening
  - DRE/PSA effective for finding early prostate cancer
  - Treatment of early disease can reduce mortality and increase survivals
- Cons of screening
  - Mortality benefit not yet shown in randomized trials
  - Routine screening can have serious residual effects (urinary, incontinence, and sexual impotence)

# The Studies

- Two studies were conducted using African-American men and mixed race populations.
- An interdisciplinary team developed an intervention.
- Intervention components created include
  - a prostate cancer screening education booklet
  - a prostate cancer screening counseling protocol

# Is Being Checked for Prostate Cancer a Good or Bad Idea?

You Have the Right to Know the Facts and Decide What to Do



Plain Talk for Men Who Have Not Had Prostate Cancer



# The Role of AHP

- The team adapted the AHP to the needs of the target groups (many illiterate).
  - limit process to only three criteria
  - rank order criteria before eliciting judgments
  - truncate the AHP scale using only 1.1-1.9 and 9.9
  - modify language used for strength of preference

# Implementing the AHP

- Two focus groups were held to pretest the intervention.
- Three systems were developed
  - A paper and pencil system
  - an Excel spreadsheet-based system
  - a programmable calculator-based system
- The programmable calculator tool was selected for use in the current project.
- Future use may include PDAs

# Status

- Data collection is complete for both studies
- Data analysis is underway
- Preliminary results indicate that clients were more satisfied with their screening decision when the AHP intervention was used
- Accepted for publication C & OR 2003

# Case Study: IV Pump Selection Project to Prevent Patient Deaths

Matthew Liberatore

Robert Nydick

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# Issues:

- “Sentinal Events” had occurred
  - Pediatric patients died, and hospital needed to replace all IV pumps for adult, pediatric, and home use
    - No single IV pump meets ALL needs perfectly
    - Each IV pump incurs significant unique, long-term disposables costs and training issues

# Process and Outcome

- We facilitated a group-based IV Pump evaluation process using Expert Choice
  - Developed an iterative process to structure and then specify the model
  - Elicited judgments and obtained group consensus in a series of 4 meetings
    - ICU, ER, Admin, Home Health, Clinical Engineering, Pediatrics/NICU
  - Identified and evaluated qualifying alternatives
- Hospital implemented complete changeover to new brand and model

# Two Additional Case Briefs

- Surgeon Decision Support Tool
  - Help select suitable patients for long (6+ hour procedure), and complicated, colorectal cancer laparoscopic resection
- Physician Computer System Selection
  - Physician practice management software for \$1 Million group practice

# Case: Colorectal Cancer Patient Selection (Researcher: Elliot Sloane)

- Minimally invasive surgical process by laparoscope takes 6+ hours by highly skilled surgical team
- The procedure will not be successful if the tumor is too big, or has spread
- The procedure may take much longer, and may be unsuccessful, based on factors like obesity, prior abdominal surgery, or other factors

# Trade-offs are being organized and analyzed

- Obesity vs. other complicating factors
- High laparoscopic surgery cost vs. traditional methods
- More rapid recovery, and higher “quality of life,” than traditional, swifter colostomy procedures
- Training of new surgeons takes additional time, but is necessary anyway

# Current status

- Still early in the process
  - Have organized the major criteria
  - Have collected outcome data and patient histories and are analyzing for criteria and weights
  - Preliminary hierarchical structure is evolving

# Case: Physician Computer System Selection (Researcher: Elliot Sloane)

- Major suburban independent family physician practice
  - > \$1 Million per year, therefore subject to upcoming HIPAA laws (EDI, security, and privacy issues)
  - ~ 20,000 patient visits/year
- The AHP model is self explanatory
  - (if possible, switch to Expert Choice here...)

# Conclusions: Clinical engineering perspectives of AHP advantages:

1. AHP is helpful because selection criteria become measurable
  - Eliminates wish lists and/or personal preferences!
2. Guides user in selecting the best hardware for the application at the best possible cost
3. Helps expose vendor options, in terms of equipment support, features, limitations
4. Selection criteria is supplied by all stakeholders, ensuring a team approach and consensus in the process

# Successful application of AHP to healthcare decisions:

- We are finding that AHP can help improve many healthcare decisions when properly facilitated
  - Doctors, nurses, administrators, and engineers appreciate the systematic approach and the learning/consensus building that occurs
- Clinical engineers, or perhaps a new breed of “hospital systems engineers,” can provide leadership and expertise to clinicians and administrators, as they may have more time and relevant expertise to master these tools
  - They also “speak the language” of healthcare and technology

# MEDICAL DECISION SUPPORT USING THE ANALYTIC HIERARCHY PROCESS

## ABSTRACT

*The Analytic Hierarchy Process for medical and hospital decision support allows the user to design a hierarchical structure and weigh the trade-offs between decision criteria and alternatives to facilitate improved clinical and management decisions.*

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**U**sing case studies, this paper describes how CEOs, CIOs, IT/IS specialists, and clinical engineers can use the Analytic Hierarchy Process (AHP) to improve the quality of diverse and important decisions that hospitals face today. AHP is a versatile and proven decision support tool that allows the user to design a hierarchical structure for decision making and weighs the trade-offs between decision criteria and alternatives.<sup>1,2</sup>

The recommended steps for examining and weighting the relative importance of the multiple criteria affecting many decisions have been summarized as:

- Identifying the alternatives available and the personal criteria on which they will be evaluated
- Determining how well the alternatives achieve personally meaningful criteria, based on an assessment of available data and personal preferences
- Assessing the importance of each criterion in the decision-making process
- Making a choice among the alternatives after synthesizing the results from the previous steps<sup>3</sup>

The process also weights the alternatives for each criterion. These recommended steps help resolve the conflicts that often exist when choosing between multiple competing criteria and alternatives.<sup>4,5</sup>

Many books and articles exist that delve into the details and applications of AHP,<sup>6-10</sup> but the following brief introduction is provided as background.

- First, AHP is a PROCESS: the process requires structuring personal criteria and evaluating the relative importance of each criterion and then determining how the alternatives achieve each of the criteria.
- Second, AHP organizes the decision into a HIERARCHY of criteria and alternatives; the criteria are organized according to perceived logical and natural groups to improve the clarity and usability of the model and to create properly proportioned subcategories that ensure all important criteria are accounted for and receive the proper weight in the decision.
- Third, AHP is ANALYTIC: it uses pairwise comparisons to help the user express the perceived relative importance of every criterion against every other criterion within

## KEYWORDS

*Analytic Hierarchy Process (AHP)    Decision support    Pairwise comparison  
Expert Choice    Collaboration    Health technology assessment*

Fall, 2002 Issue  
Journal of Healthcare  
Information Management

[www.HIMSS.org](http://www.HIMSS.org)

There's much more DSS work to be done in healthcare. AHP is only part of the answer; hope you are interested in helping us do more!

**Thank you! We welcome your questions and comments!**

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