1. Background

Healthcare is a central political, economic and social issue of our times. In the healthcare process, decisions are made at every level from the treatment of individual patients to formulation and evaluation of national policies. At the same time, data generation is increasing dramatically. Electronic medical records are becoming ubiquitous. Tests produce gigabytes of data, including images and biometric samples. The volumes of data are daunting in themselves; concomitant problems such as confidentiality and data quality exacerbate the challenges in producing usable tools that support principled healthcare decisions.

2. Personnel

The Program Leaders were Sheldon Jacobsen (University of Illinois at Urbana-Champaign), Myron Katzoff (National Center for Health Statistics/CDC), Mark Lewis (Cornell University), Avi Mandelbaum (Technion), Marianne Markatou (IBM), Alan Menius (GlaxoSmithKline) Robert Obenchain (Risk Benefit Analysis), William Shannon (Washington University in St. Louis).

Local Scientific Coordinators were Nilay Argon (University of North Carolina at Chapel Hill), Julie Ivy (North Carolina State University), Vidyadhar Kulkarni (University of North Carolina at Chapel Hill), and Stanley Young (National Institute of Statistical Sciences)
The SAMSI Directorate Liaison was Alan Karr, and the National Advisory Committee Liaison was Susan Murphy (University of Michigan).

The principal visitors to the program were

- Myron Katzoff (formerly National Center for Health Statistics/CDC),
- Avi Mandelbaum (Technion)
- Robert Obenchain (Indiana University and Risk Benefit Statistics)
- Joseph Stanford (MD, University of Utah)

Faculty releases were:

- Nilay Argon (UNC STOR)
- M. Gregory Forest (UNC Applied Mathematics)
- Vidyadhar Kulkarni (UNC STOR)
- Eric Laber (NCSU Statistics)

Graduate students (and advisers) were:

- A. Hoover (UNC Applied Mathematics; Forest)
- K. Linn (NCSU Statistics; Laber)
- Z. Sun (UNC STOR; Argon)
- H. Ye (UNC STOR; Argon)

The sole postdoctoral fellow was Kenneth Lopiano (Ph.D., Statistics, University of Florida, 2012).

3. Workshops

The Opening Workshop was held on August 26-29, 2012. Attendance was approximately 100. The program comprised tutorials by Marianthi Markatou (IBM) on comparative effectiveness research and Avi Mandelbaum (Technion) on data-based service systems, a keynote address “Connections Between OR and CER” by Sheldon Jacobson (University of Illinois), ten other invited presentations, poster sales talks, an open mike session and a concluding panel discussion that laid the ground for formation of the working groups.

The Transition Workshop was held on May 9-10, 2013, with a total attendance of forty. It focused on presentation and discussion of research carried out during the year by the Working Groups on Patient Flow, Dynamic Treatment Regimes, OMOP Data, and Observational CER.

Because of the scale and nature of the program, no workshops were held during the year.

The programs for the Opening and Transition Workshops are appended to this report.
4. Program Course

One course was held under the auspices of the program, with approximately 15 attendees:

**Course Title:** Operations Research Methods in Healthcare

**Principal Instructor:** V. Kulkarni, UNC

**Schedule:** Wednesday, 4:30-7:00 PM, September 5 - December 6, 2012

**Course Description:** A seminar-style course treating application of operations research methods such as stochastic modeling, queuing theory (including fluid models), optimization and simulation to problems in healthcare. Potential problems studied were data-based design of healthcare operations, patient flow, scheduling of facilities and personnel, management of transplant lists, mass casualty events and comparative effectiveness research. Students read and made presentations of material from the relevant literature.

5. Working Groups

The following Working Groups were active throughout the program year.

**Dynamic Treatment Regimes**, led by Eric Laber (North Carolina State University). The goal of the working group was to bring new quantitative researchers into the field of dynamic treatment regimes. Thus, seminars and tutorials by experts in this area formed a major part of the working groups activities. Another goal of the group was the formation of smaller, more focused, subgroups working on specific research projects. These subgroups presented their research to the working group for comments and feedback. Finally, the group acted as a sounding board for its participants; in particular, they conducted case studies wherein a member brings their data and planned analysis for critique.

**Distributed Health Services**, led by Monica Jackson (American University) and Otis Jennings (Columbia University). The Working Group covered topics relating to public health and health concerns not currently addressed by a single existing facility. Members investigated topics such as emergency transport, community-based interventions, mobile health units, the intersection of disease propagation and health facility preparedness, certificate of need, and facility placement.

**Data-Based Research on Patient Flow**, led by Mandelbaum and Nilay Tanik Argon (University of North Carolina at Chapel Hill). The main objective of this very large working group was to use data to make better decisions about patient flow and resource allocation decisions in hospitals, clinics, and any other health care settings. Particular goals that were pursued included: (a) Comparison of practices/protocols at different types of hospitals at different countries; (b) Development of tools that would help optimize, estimate, predict, and make decisions at
individual levels that would contribute to the area of individualized medicine; (c) Estimation of triage errors and development of methods to take them into account in decision making at various levels (daily triage at ED, mass-casualty triage, and disaster/military triage); (d) Analysis of challenging modeling constructs that arise from healthcare such as time-varying (transient) models (vs. steady-state) and fork-join delays; (e) Development of flexible simulation tools to simulate operational and possibly clinical protocols, interconnected units, etc. that allow customization; and (f) Study of behavioral aspects of patients in hospitals. How do patients make decisions (e.g., leave without being seen or against medical advice)? What are the psychological factors driving patient decisions in hospitals, or elsewhere?

**Observational Comparative Effectiveness Research (OCER),** led by Robert Obenchain and S. Stanley Young. The goals were to (1) Advocate practices that make OCER a highly relevant and genuinely creditable alternative to Randomized Clinical Trials (RCTs) for improving current health care practice; (2) Propose and advocate methods for identification of Heterogeneous Treatment Effects (HTEs, which provide an objective basis for Individualized Medicine / Patient-Centered Outcomes Research (PCOR); (3) Champion initiatives to encourage and/or enforce OCER data sharing. Data sharing assures that key findings are “consensus views” that are not only objective but also reproducible; and (4) Develop and advocate use of interactive graphical displays of OCER information to enhance Doctor-Patient dialogs on treatment choices and to provide more realistic and easily interpretable information about uncertainty in outcomes.

**Observational Medical Outcomes Partnership (OMOP) Data,** led by Alan Karr (NISS) and Patrick Ryan (OMOP). The goals of the Working Group were (1) Analysis of the OMOP results database (http://omop.fnih.org/Research), leading to multiple publications, the first of which was submitted in November, 2012; and (2) Assessment of the representativeness of OMOP databases, which is crucial to assessing the broader applicability of observational medical studies.

**Management of Chronic Diseases,** led by Julia Ivey (North Carolina State University). The goal of the Working Group was to OR and statistical modeling tools (examples: Markov decision processes (MDP), partially observable MDP and multi-agent models to modeling of chronic diseases. Requirements for utilizing these modeling tools are metrics for measuring a “good” decision, methods for capturing disease progression, and methods for defining and characterizing the “state” of the system. Challenges included the need to capture patient preference, data analysis to capture the disease dynamics which requires time series and other longitudinal modeling of data that is often sparse or intermittent, quantitative and qualitative, with missing observations, and managing data from multiple sources.

### 6. Products of the Program

This section is incomplete because not all Working Group Leaders and other participants responded to requests to furnish relevant information. No works in progress are included.
6.1 Research Papers


Liu, N. (2014). “Optimal Choice for Appointment Scheduling Window under Patient No-show Behavior.” Submitted for publication. (Winner of the third place in the 2013 INFORMS Junior Faculty Interest Group (JFIG) Paper Competition.)


6.2 Selected Presentations

Karr, A. F.: “Analysis of the OMOP Results Database: Does the Analysis Method Matter More than the Truth?” Department of Biostatistics and Bioinformatics, Georgetown University, April 2013.


Laber, E.: Presentations at Atlantic Causal Inference Conference, Brown University, Providence, RI, May 2014; Midwest Biopharmaceutical Statistics Workshop, Ball State University, Muncie, IN, May 2014; Trends and Innovations in Clinical Trial Statistics Conference, Morrisville, NC, April 2014; Department of Biostatistics, University of Pittsburgh, Pittsburgh, PA, April 2014; NIPS, Workshop on Causality and Experimental Design, Lake Tahoe, NV, December 2013; INFORMS, Minneapolis, MN, October 2013; Society for Medical Decision Making,
Baltimore, MD; y-BIS, Istanbul, Turkey, September 2013; Joint Statistical Meetings, Montreal QC, August 2013; ENAR, Orlando, FL, March, 2013.


Qian, M.: “Experimental design for comparing adaptive interventions,” Center for Behavioral Cardiovascular Health, Department of Medicine, Columbia University Medical Center


6.3 Proposals


NSF SBIR Proposal, PI = K. Lopiano, December 2013

NIH SBIR Proposal: PI = K. Lopiano, April 2014 (with Duke collaborators)

EPRI Proposal: Development of a Medicare Cohort Dataset for Use in Air Pollution Epidemiological Research. PI = S. S. Young (NISS), June 2014

NSF STTR Proposal: PI = K. Lopiano, June 2014 (with East Carolina University and University of Florida collaborators)
6.4 Ongoing Collaborations

Collaboration between NISS and American Society for Clinical Oncology (ASCO), led by NISS acting director Nell Sedransk and ASCO Chief Medical Officer Richard Schilsky (catalyzed by DDDHC postdoc K. Lopiano and former NISS director A. Karr)

Lopiano, K.: Continuing collaboration with UNC-Chapel Hill to conduct research regarding patient flow in emergency departments: Jeffrey Strickler, Debbie Travers, Nilay Argon, Serhan Ziya

Lopiano, K.: Continuing collaboration with Duke University to conduct research regarding clinical decision support for anticoagulation management: Deepak Voora

Lopiano, K.: Continuing Collaboration with East Carolina University to conduct research regarding patient flow in emergency departments: Timothy Reeder

Lopiano, K.: Continuing Collaboration with University of Florida to conduct research regarding patient flow in emergency departments: Adrian Tyndall


6.5 Spinoff Corporation

Roundtable Analytics, LLC, Winterville, NC. Founder and Principal Collaborator is DDDHC postdoc Kenneth Lopiano.
## SAMSI 2012-13 Program on Data-Driven Decisions in Healthcare
### Opening Workshop
#### Schedule

**Sunday, August 26, 2012**  
**Radisson RTP**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:15-9:45 a.m.</td>
<td>Registration and Continental Breakfast</td>
</tr>
</tbody>
</table>
| 9:45-10:00  | Welcome and Introduction  
*Alan Karr*, NISS                                                   |
| 10:00-11:15 | Tutorial: Comparative Effectiveness Research: An Overview and Some Methodological Challenges  
*Marianthi Markatou*, IBM                                     |
| 11:15-11:30 | Break                                                                |
| 11:30-12:30 | Tutorial Cont’d: Comparative Effectiveness Research: An Overview and Some Methodological Challenges  
*Marianthi Markatou*, IBM                                     |
| 12:30-1:30  | Lunch                                                                |
| 1:30-2:45   | Tutorial: Data-Based Service Networks: A Research Framework for Asymptotic Inference, Analysis and Control of Service Systems  
*Avi Mandelbaum*, Technion                                      |
| 2:45-3:00   | Break                                                                |
| 3:00-4:00   | Tutorial Cont’d: Data-Based Service Networks: A Research Framework for Asymptotic Inference, Analysis and Control of Service Systems  
*Avi Mandelbaum*, Technion                                      |

**Monday, August 27, 2012**  
**Radisson RTP**

<table>
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<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>8:00-8:30 a.m.</td>
<td>Registration and Continental Breakfast</td>
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</tbody>
</table>
| 8:30-8:45  | Welcome and Introduction  
*Alan Karr*, NISS                                                   |
| 8:45-9:45  | Keynote: *Connections Between OR and CER*  
*Sheldon Jacobson*, University of Illinois                          |
| 9:45-10:00 | Break                                                                |
| 10:00-12:00| Technical Session: Screening and Treatment of Chronic Diseases       |
Can We Do Better than “One Size Fits All”? OR Models for Screening and Treatment

Julie Simmons Ivy, North Carolina State University

Data-Driven Medical Decision Making of Chronic Disease Patients

Mariel Lavieri, University of Michigan

Discussant: Turgay Ayer, Georgia Tech

12:00-2:00 Lunch

2:00-4:30 Technical Session: Valid Prediction from Medical Observational Data

A Predictivist Approach to Observational Analyses in Healthcare

David Madigan, Columbia University

Nonparametric Preprocessing for Head-to-Head OCER* Predictions

Robert Obenchain, Risk Benefit Analysis

Discussant: Stanley Young, NISS

4:30-5:30 Participatory Session: Poster Advertisements

5:30-7:30 Reception and Poster Session

Tuesday, August 28, 2012
Radisson RTP

8:00-8:30 a.m. Registration and Continental Breakfast

8:30-10:00 Technical Session: Patient Flow

Staffing to Stabilize Customer Delays in Service Systems with Time-Varying Arrivals

Yunan Liu, North Carolina State University

ICU Congestion: The Impact on Patient Flows

Carri Chan, Columbia University

10:00-10:15 Break

10:15-12:00 Technical Session Cont’d: Patient Flow

Mathematical Models for Hospital Inpatient Flow Management

Jim Dai, Cornell University and Georgia Tech

Discussant: Guodong Pang, Pennsylvania State University

12:00-2:00 Lunch

2:00-4:15 Technical Session: Healthcare CER
<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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</thead>
<tbody>
<tr>
<td>4:15-4:30</td>
<td>Break</td>
</tr>
<tr>
<td>4:30-5:30</td>
<td>Participatory Session: Open Mike Session</td>
</tr>
</tbody>
</table>

**Wednesday, August 29, 2012**  
**Radisson RTP**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>8:00-8:30 a.m.</td>
<td>Registration and Continental Breakfast</td>
</tr>
<tr>
<td>8:30-10:00</td>
<td>Technical Session: OMOP Research and Data</td>
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<td></td>
<td><em>Lessons from the Observational Medical Outcomes Partnership:</em></td>
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<td></td>
<td><em>Opportunities for Exploring Healthcare Databases to Study the Effects of Medical Products</em></td>
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<td><em>Patrick Ryan, OMOP</em></td>
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<td>Discussant: <em>Alan Menius, GlaxoSmithKline</em></td>
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<tr>
<td>10:00-10:30</td>
<td>Break</td>
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<tr>
<td>10:30-12:00</td>
<td>Panel Discussion: Research Priorities for the DDDHC Program</td>
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<tr>
<td></td>
<td><em>Sheldon Jacobson, University of Illinois</em></td>
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<td><em>Avi Mandelbaum, Technion</em></td>
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<td><em>Marianthi Markatou, IBM</em></td>
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<td><em>Sally Morton, University of Pittsburgh</em></td>
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<tr>
<td>12:00-1:00</td>
<td>Lunch</td>
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<tr>
<td>1:00-3:00</td>
<td>Open Discussion: Proposals for Working Groups and Working Group Formation and Initial Meetings</td>
</tr>
</tbody>
</table>
Data-Driven Decisions in Healthcare Transition Workshop
May 9-10, 2013
SCHEDULE

Thursday, May 9
SAMSI

8:30-9:00 Registration and Continental Breakfast
9:00-9:15 Welcome and Introductions

Patient Flow

9:15-9:45 Nilay Tanik Argon, UNC and Avi Mandelbaum, SAMSI and Technion
“Data-Based Research on Patient Flow: Working Group Progress and Individual Adventures”

9:45-10:15 Nan Liu, Columbia University
“Patient Preferences in Appointment Scheduling: Empirical Estimation and Operations Modeling Opportunities”

10:15-10:30 Break
10:30-11:00 Petar Momcilovic, University of Florida
“Queueing Perspective of Patient Flow: Towards Personalized Models”

11:00-11:30 Amy Ward, University of Southern California
“Modeling Patient Flow in Emergency Departments using Fork-Join Networks”

11:30-12:00 Discussion
12:00-1:30 Lunch

Dynamic Treatment Regimes

1:30-2:00 Kristin Lynn, North Carolina State University
“Smooth Estimation of Optimal Dynamic Treatment Regimes”

2:00-2:30 Yingqi Zhao, University of Wisconsin Madison
“Statistical Learning Methods for Estimating Optimal Dynamic Treatment Regimes”

2:30-3:00 Discussion
3:00-3:30 Break
OMOP Data

3:30-4:00  Rebecca Ferrell, University of Washington
"Challenges of Analyzing OMOP "Big Results" and Some Visual Approaches"

4:00-4:30  Alan Karr, NISS
"Analysis of the OMOP Results Database -- Does the Method Matter More than the Truth?"

4:30-5:00 Discussion

5:00-7:00 Poster Reception
SAMSI will provide poster presentation boards and tape. The board dimensions are 4 ft. wide by 3 ft. high. They are tri-fold with each side being 1 ft. wide and the center 2 ft. wide. Please make sure your poster fits the board. The boards can accommodate up to 16 pages of paper measuring 8.5 inches by 11 inches.

Friday, May 10
SAMSI

8:30-9:00 Continental Breakfast

Observational CER

9:00-9:30 Kenneth Lopiano, SAMSI
"sNMF for Sparse Data and Method for Determining Matrix Degree from Noisy Data"

9:30-10:00 Kumer Das, Lamar University
"Contingency Table Analysis via Matrix Factorization"

10:00-10:30 Myron Katzoff, CDC (retired)
"Recursive Partitioning Applied to Complex Sample Survey Data"

10:30-10:45 Break

10:45-11:15 Robert Obenchain, Risk-Benefit Analysis
"Local Control Methodology"

11:15-11:45 Stanley Young, NISS
"Status of Datasets"

11:45-12:30 General Discussion: Future Directions and Collaborations

12:30 Workshop Adjourns: Lunch Available for Participants