WORKSHOP
ISPOR DC

W5: CONSTRAINED OPTIMIZATION: *WHY MAKING PIZZA AND MAXIMIZING HEALTH CARE VALUE ARE THE SAME PROBLEM*

ISPOR
Operations Research Optimization Methods Emerging Good Practices Task Force

Session Outline

1) Background on the Optimization Task Force
2) Introduce Optimization
3) Relevance in health care delivery
4) Let's make pizza!
5) Examples of health care decision making
6) Structure of an optimization model
7) How is optimization different from statistics, data mining and simulation?
8) Discussion

Optimization Methods in Health Care Delivery

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Constrained Optimization CONOPT Task Force Background

Builds on the ISPOR Dynamic Simulation Modeling (DSM) Applications in Health Care Delivery Research TF Reports (2015):

1. Applying Dynamic Simulation Modeling Methods in Health Care Delivery Research—The SIMULATE Checklist

   System, Interactions, Multi-level, Understanding, Loops, Agents, Time, Emergence
2. Selecting a Dynamic Simulation Modeling Method for Health Care Delivery Research—Part 2

   Criteria for selecting based on: a) type of problem; b) the object; and c) method to model the object

http://www.ispor.org/simulation-modeling-apps-hc-delivery.asp

CONOPT Task Force Background

Dynamic Simulation Models:

- Test ‘what if ‘ scenarios and evaluate intended and unintended outcomes from interventions or policy changes
- Examples: system dynamics, discrete event simulation and agent based modeling

‘Optimal’ Models

- Provide best possible solution for a given problem given the complexity of the system inputs, outputs/outcomes, and constraints.
- Not always possible to solve the optimization problem for all problems
- Growing recognition of the applicability of optimization methods to health care problems.

Optimization and HEOR

- Health economics can (and does) ***draw on*** optimisation techniques in the same as way as it draws on statistics

- As ***big data*** play a greater role in health care
  - more automation of healthcare
  - greater personalisation of medicines

- Expect that we will see more and more use of optimization methods…

Applications of Optimization

- Capacity management and location selection for healthcare services and supplies
- Patient scheduling, provider resource scheduling, and logistics
- Diagnosing disease and the development of optimal treatment algorithms
- Identify optimal allocation of resources across interventions subject to a variety of different types of constraints in health care

Rais, A., Viana, A. Operations Research in Healthcare: a survey. Intl. Trans. In Op. Res. 18(2010) 1-31

CONOPT Task Force Objectives

(1) Introduce the value of optimization methods in conducting research on health care systems and individual-level outcomes research;

(2) Describe problems for which operations research optimization methods are appropriate; and

(3) Identify good practices for designing, populating, analyzing, testing and reporting high quality research for optimizing healthcare delivery services at both the systems and individual level.

http://www.ispor.org/TaskForces/Optimization-in-Healthcare-background-contd.pdf

CONOPT Task Force Objective

Develop guidance for researchers and decision makers on constrained optimization methods applied in health care delivery system interventions research.

The task force will:

1) provide an overview of constrained optimization (CONOPT)
2) describe when CONOPT is appropriate to address the problem and relate it to pizza making
3) provide examples of CONOPT that have been used to address health care delivery problems.

What is Optimization?

- **Optimization** is a key tool in the ***analytics armamentarium.***
  - "**Optimization:** Narrowing your choices to the very best when there are virtually innumerable feasible options and comparing them is difficult" INFORMS, The Science of Better http://www.scienceofbetter.org/what/index.htm
  - "In a mathematical programming or **optimization** problem, one seeks to minimize or maximize a real function of real or integer variables, subject to constraints on the variables." The Mathematical Programming Society http://www.mathprog.org/mps_whatis.htm
- **Take home**: Optimization is an ***applied, practical*** subject, but also a ***highly technical*** one that uses cutting edge math and computation

Rationale

- **'Optimal' System Design**

  Traditional statistics and simulation-based studies are prevalent. While such approaches can help provide descriptives and test hypotheses, they are unable to provide optimal prescriptive solutions.

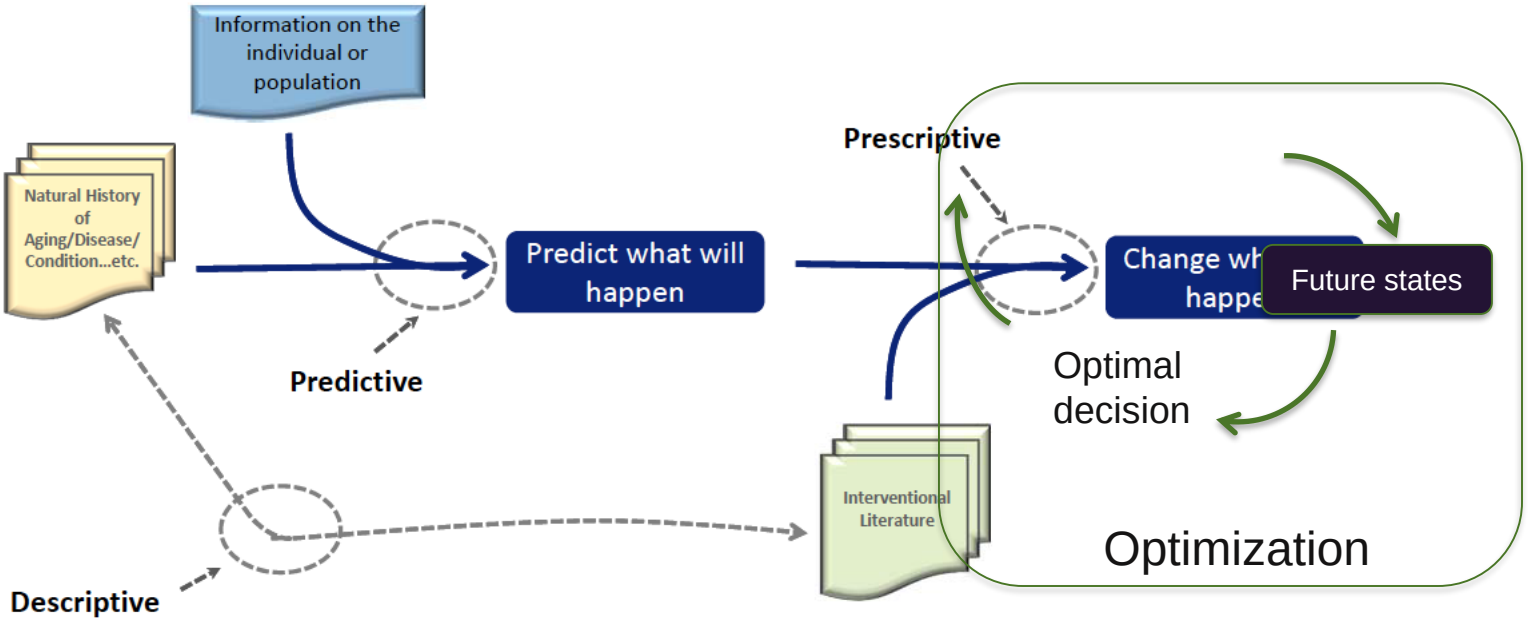
- **Growth in Use of Optimization Methods**

  Modeling work in areas of operations, policy and medical decision making.

- **Provide Guidelines and Focus on Practical Implications**

  TF would disseminate knowledge of such methods, serve as a primer for use engaged in outcomes and policy research, and provide guidelines/recommendations.

Optimization and Link to Analytics



Wilson, ISPOR 2014

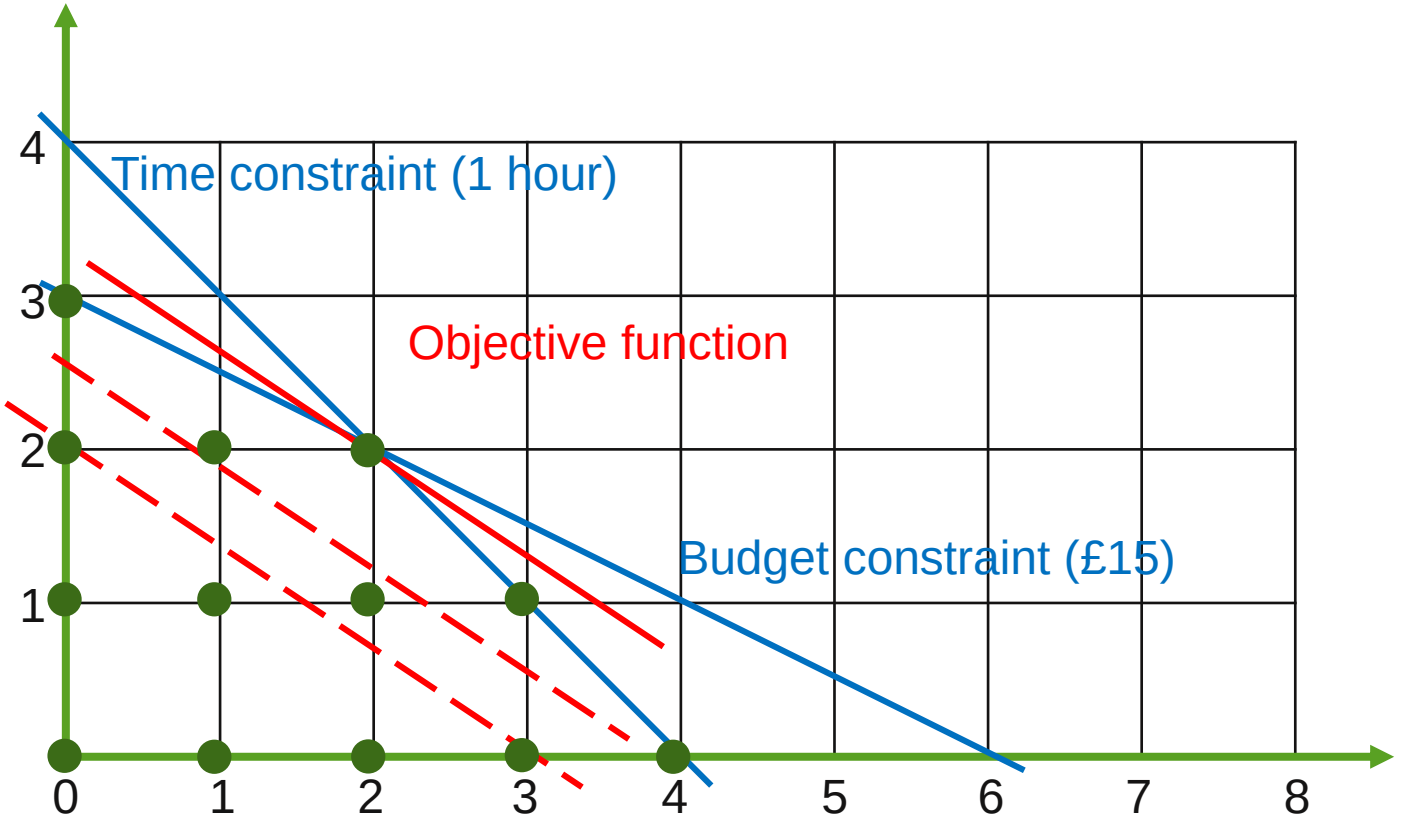
Let’s make Pizza!

Pizza problem

- Setting: Movie night at your place
- Food Options: Regular or Large Pizzas
- Some info:
  - Regular pizzas can feed 2, Large ones can feed 3 people
  - Regular pizza costs £2.50, large pizza is £5
  - Each pizza takes fifteen minutes to cook, total oven time available is an hour
  - Can only put one pizza at a time
  - Total money available is £15
- Question: What's the most number of people you can feed?

Pizza problem – Graphical representation

Large Pizza



Regular Pizza

Pizza problem – Optimization model

Parameters:

- c_R, c_L = cost of regular and large pizza, respectively
- B = total budget available
- t_R, t_L = time to make regular and large pizza, respectively
- T = total time available
- f_R, f_L = number of people a regular and large pizza can feed, respectively

Decision variables:

- x_R, x_L = number of regular and large pizzas to make, respectively

Pizza problem – Optimization model

Optimization Model

$$\max \quad f_R x_R + f_L x_L \qquad \text{(objective function)}$$

$$\text{subject to} \quad c_R x_R + c_L x_L \leq B \qquad \text{(budget constraint)}$$

$$t_R x_R + t_L x_L \leq T \qquad \text{(time constraint)}$$

$$x_R, x_L \geq 0 \text{ and integer}$$

Model Data:

- f_R = 2 people, f_L = 3 people
  - c_R = £2.50, c_L = £5, B = £15
- t_R =0.25 hours, t_L = 0.25 hours, T = 1 hour

Pizza making and Healthcare

	Pizza problem	Health Care	Terminology
Options available	Regular or large pizzas	pharma, bundled episodic payment models, ortho, hip/knee, etc	Decision variables
Constraints	Total cost < £15	Budget constraint	Constraints
Aim	Maximize number of people to feed	Maximize health care benefits	Objective function
Evidence base	Cost of each pizza, how many people it can feed and the time taken to cook	Costs of each intervention, health benefits, and any other relevant data	Model (to determine the objective function and Constraints)
Complexity	One-off, deterministic, static problem	Repeated, stochastic, dynamic problem	Optimization method

Complexity - Pizza vs Health Care

Complexity	Pizza problem	Health Care
Static vs Dynamic	Static (i.e. one-off) problem. If the pizza problem was solved for multiple time periods, then it will become dynamic problem	Dynamic problem. Health care is constantly evolving – changing budgets, new policies, new interventions, etc
Deterministic vs stochastic	All the information is assumed to be certain (e.g. costs of the pizza, how many it can feed, how long it will take to cook)	Know that the information is uncertain (i.e. uncertainty in the costs and benefits of the interventions)
Linear vs Non-linear	Linear (i.e. each additional pizza costs the same and feeds the same number of people)	Non-linear (e.g. Quality/outcomes maybe non-linear, also interactions between the interventions, etc)

Examples of Health Care Decisions Using Optimization

Examples application areas include:

- Resource allocation within and across disease programs
- Workforce Planning
- Staff scheduling
- Inpatient Scheduling
- Outpatient Scheduling
- Developing screening/preventive health policies
- Planning prevention and treatment programmes for infectious diseases
- Hospital facility location
- Radiation Therapy Planning
- Organ Donation planning
- Resource allocation within and across disease programs
- Disease management planning

- … and many more!

Next Steps

- Task Force progress
  - Working meeting at ISPOR DC
  - First draft ready by September 2016
  - European Congress, Vienna, November 2016
  - Internal and external review in Fall 2016
  - Final draft and submission January 2017

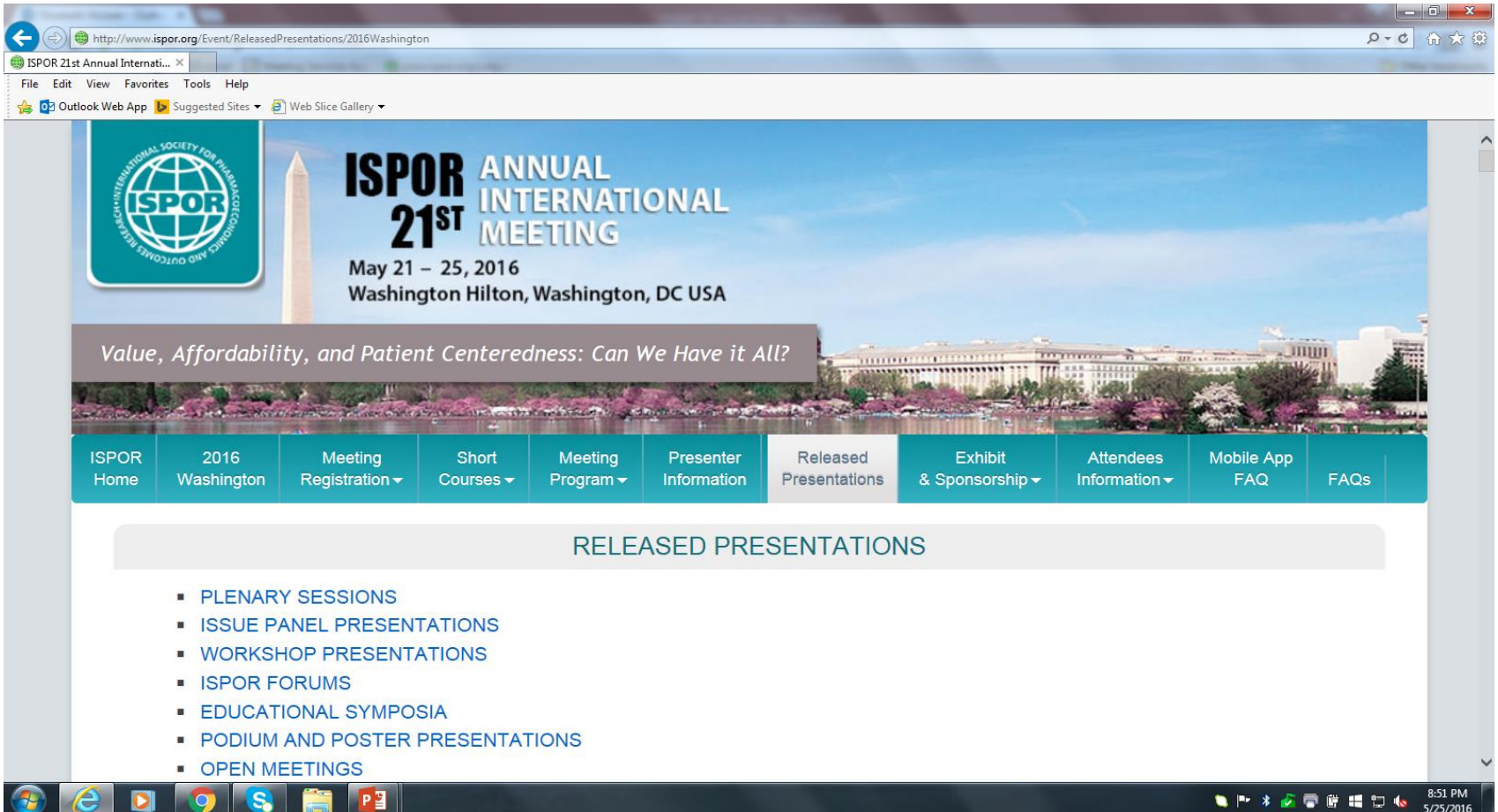
Please JOIN our Task Force Review Group

1. Go to the ISPOR homepage: www.ispor.org .
2. Click on the GREEN TASK FORCE menu at the TOP of the homepage
3. Select JOIN on the pull-down menu.

Forum Slides

FORUM SLIDES are AVAILABLE!

http://www.ispor.org/Event/ReleasedPresentations/2016Washington



Questions?