2017 CHEPS Healthcare Executive Summit

CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
UNIVERSITY OF MICHIGAN

Using OpenSolver for Scheduling Medical Trainees

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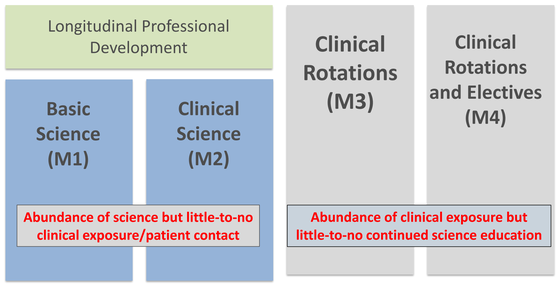
Background

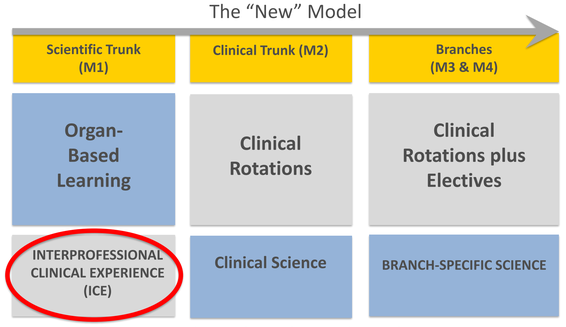
- The U.S. physician training process is shifting
- Changes have included development of a new Medical College Admission Test (MCAT) and modifications to medical school curricula nationwide
- New curricula replace the traditional 2+2 format with continued science education and clinical exposure throughout medical school

The "Old" Model



Adapted from http://curriculum.med.umich.edu/faqs

The "New" Model



Adapted from https://medicine.umich.edu/medschool/education/md-program/curriculum/diagrams

- The University of Michigan Medical School recently began implementing a new curriculum with the above goals in mind
- Changes included the creation of an Interprofessional Clinical Experience (ICE), designed to provide first year medical students (M1's) with longitudinal exposure to the clinical environment

Problem Statement

- ICE is designed to expose students to a variety of clinical environments, but raises a number of scheduling issues
- Schedules must assign approximately 170 M1's to clinics in which they shadow healthcare professionals subject to numerous rules

Winter Session Model

Sets

S	set of students
C	set of clinics
C_O	subset group of Outpatient-Based clinics
C_H	subset group of Hospital-Based clinics
C_P	subset group of on-site clinics
C_D	subset group of off-site clinics
C_R	subset group of off-site clinics that require cars for every student

Parameters

l_c	1 if clinic c is open
u_c	upper bound capacity for clinic c
z_s	1 if student s has a car
j_s	1 if student s has a car, -1 otherwise
p_{sc}	1 if student s cannot be assigned to clinic c due to prior clinic assignment
t_{sc}	1 if student s needs an assignment to clinic type c
m_s	1 if student s is taking Medical Spanish
a_{sc}	1 if student s prefers clinic c with the highest preference
b_{sc}	1 if student s prefers clinic c with the second highest preference
d_{sc}	1 if student s prefers clinic c with the third highest preference
f_{sc}	1 if clinic c is the least preferred clinic by student s
g_{sc}	1 if clinic c is the second least preferred clinic by student s

Decision Variables

x_{sc}	1 if student s is assigned to clinic c	$\forall\, s \in S, c \in C$

Constraints

(1) Student Coverage Requirements

Every student s must be assigned to exactly one clinic c

$$\sum_{c \in C} x_{sc} = 1, \qquad \forall s \in S$$

(2) Clinic Capacity Requirements

The number of students assigned to clinic c must be at least 1 if open and not exceed clinic capacity u_c

$$l_c \leq \sum_{s \in S} x_{sc} \leq u_c\,, \qquad \forall c \in C$$

(3) Student Car Requirements

Only those students s with a car are allowed to be assigned to a clinic c that requires a car.

$$x_{sc} \leq z_s, \qquad \forall s \in S, c \in C_R$$

(4) Student Carpooling Requirements

Students without a car may be assigned to off-site clinics, but for every student s without a car, there must be one student s with a car, such that the net number of drivers at a given clinic is greater than or equal to 0.

$$\sum_{s \in S} j_s x_{sc} \geq 0, \qquad \forall c \in C$$

(5) Prior (and similar) Clinic Assignment Prohibitions

Students cannot be assigned to the same clinic as they were assigned for fall semester or a clinic that is similar to their fall clinic assignment.

$$x_{sc} + p_{sc} \leq 1, \quad \forall\, s \in S, c \in C$$

(6) Medical Spanish Location Restriction

A student s taking Medical Spanish cannot be assigned to an off-site clinic c.

$$x_{sc} + m_s \leq 1, \quad \forall\, s \in S, c \in C_D$$

Objective Function: Minimize

$$\text{Most Preferred Assignments}\left\{-3\sum_{s \in S}\sum_{c \in C} a_{sc}x_{sc}\right. \quad \left.-\sum_{s \in S}\sum_{c \in C} t_{sc}x_{sc}\right\}\text{Correct Type Assignments}$$

$$\text{Second Most Preferred Assignments}\left\{-2\sum_{s \in S}\sum_{c \in C} b_{sc}x_{sc}\right. \quad \left.+2\sum_{s \in S}\sum_{c \in C} f_{sc}x_{sc}\right\}\text{Least Preferred Assignments}$$

$$\text{Third Most Preferred Assignments}\left\{-\sum_{s \in S}\sum_{c \in C} d_{sc}x_{sc}\right. \quad \left.+\sum_{s \in S}\sum_{c \in C} g_{sc}x_{sc}\right\}\text{Second Least Preferred Assignments}$$

Solution Approach

- We formulated a linear programming model and implemented in a Microsoft Excel workbook, using the OpenSolver add-in

Sample Inputs

Last	First	Doctoring Group	Vehicle?
Doe	John	A-Fitzbutler: 1.1	No
Gupta	Sandeep	A-Fitzbutler: 2.1	Yes
Johnson	David	A-Fitzbutler: 3.1	Yes
Lee	Michael	A-Fitzbutler: 1.1	No
Smith	Carson	A-Fitzbutler: 4.1	Yes
Waidley	Victoria	A-Fitzbutler: 4.2	Yes

Clinics	Emergency Medicine	Hospitalist A	Hospitalist B	PM&R - Inpatient	EAA, Med/Peds
Tuesday 1 (Fitzbutler)	6	8	0	6	3
Tuesday 2 (Salk)	6	8	0	6	3
Thursday 1(Hamilton)	6	0	8	6	3
Thursday 2 (Sanford)	6	0	8	6	3
Onsite Location?	Yes	Yes	Yes	Yes	Yes

Sample Output

Name	Subgroup	Emergency Medicine	Hospitalist A	Hospitalist B	PM&R - Inpatient	EAA, Med/Peds
Doe, John	A-Fitzbutler: 1.1	0	0	1	0	0
Gupta, Sandeep	A-Fitzbutler: 2.1	0	0	0	0	1
Johnson, David	A-Fitzbutler: 3.1	0	0	0	1	0
Lee, Michael	A-Fitzbutler: 1.1	0	0	0	1	0
Smith, Carson	A-Fitzbutler: 4.1	0	0	1	0	0
Waidley, Victoria	A-Fitzbutler: 4.2	0	0	1	0	0

Sample Final Schedule

House A - Fitzbutler			September 1	September 15	October 13	October 27
Name	Subgroup	Site Fall	Rotation 1	Rotation 2	Rotation 3	Rotation 4
Doe, John	A-Fitzbutler: 1.1	Hospitalist B	PT/OT, UH	Phys, UH South	Pharm, Mott	Neonatal NP
Gupta, Sandeep	A-Fitzbutler: 2.1	EAA, Med/Peds	Pharmacist	Nurse	Physician	Medical Asst
Johnson, David	A-Fitzbutler: 3.1	PM&R-Inpatient	Physician	Nurse	Rec Therapy	Social Work
Lee, Michael	A-Fitzbutler: 1.1	PM&R-Inpatient	Nurse	OT	Social Work	Rec Therapy
Smith, Carson	A-Fitzbutler: 4.1	Hospitalist B	Phys, UH South	Pharm, Mott	Neonatal NP	Resp Therapy
Waidley, Victoria	A-Fitzbutler: 4.2	Hospitalist B	Nursing, 12 West	PT/OT, UH	Phys, UH South	Pharm, Mott

Impact/Results

- Generated full schedules rapidly (solve time < 15 seconds)
- Collaborated with program directors to fine-tune assignments
- Applied tool to schedule four semesters to date
- Output number of rule violations, and where these violations are occurring, for directors' review
- Reduced program administrator burden
- Improved medical student satisfaction by incorporating preferences
- Derived high impact from mathematically simple, straight-forward modeling with undergraduate-led project team
- Fostered long-term collaboration with the medical school

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