Optimal Long Term Nurse Staffing Considering Absenteeism and Demand Uncertainty

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Effects of Increased Nursing Levels

On Patients

- Decreased patient mortality rates
- Shorter patient length of stay
- Decrease in medication errors
- Lower odds of several patient adverse events
- Higher nurse-reported quality of care

On Nurses

- Decrease in nurse burnout rates
- Increase in nurse satisfaction

On Costs

- Already 15% of hospital costs

Effects of Increased Nursing Levels

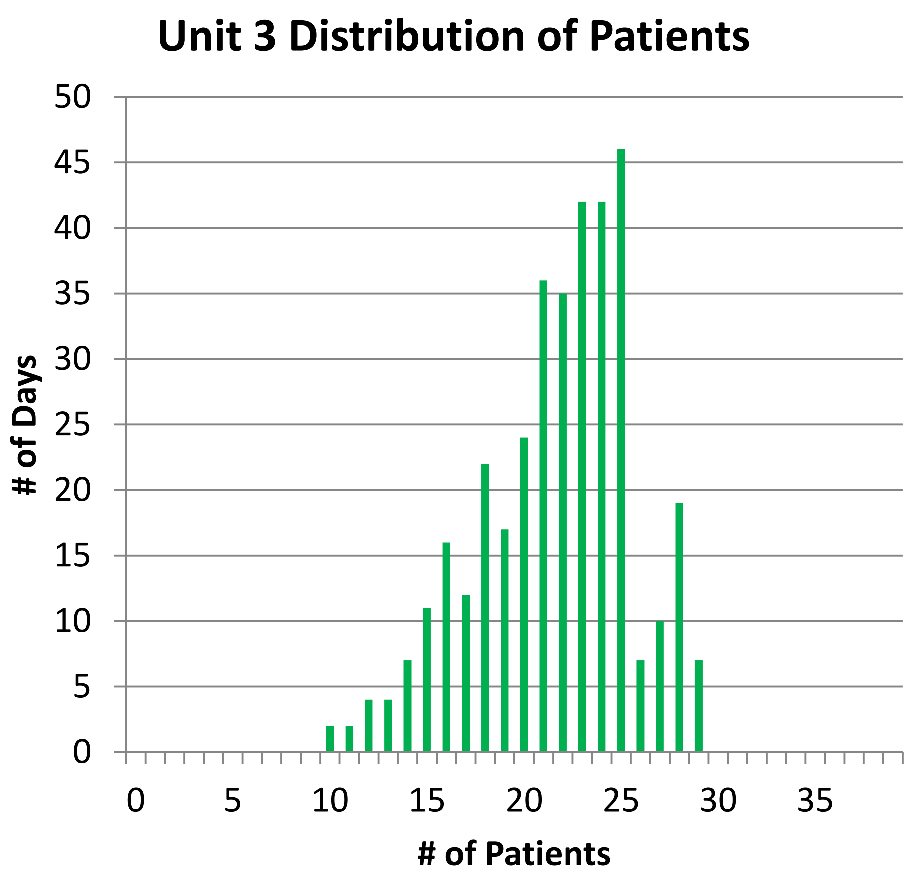
More nurses

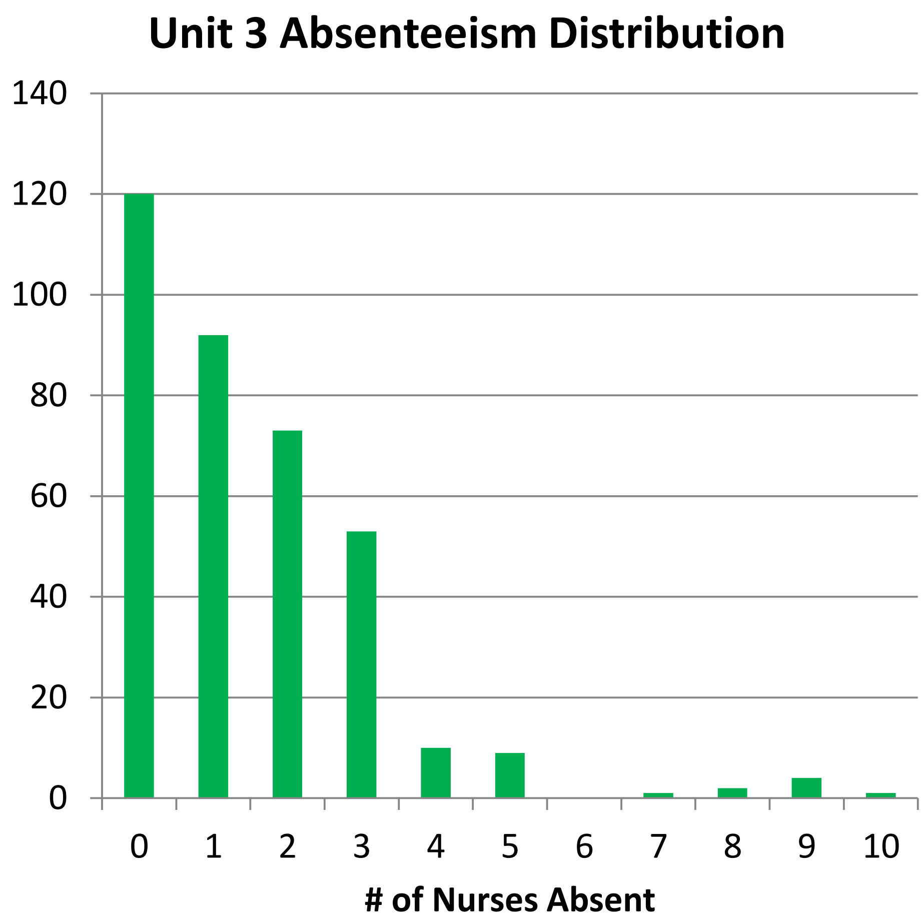
Better for
Patients &
Nurses

More nurses

Higher cost;
Already 15%
Of Hospital Costs

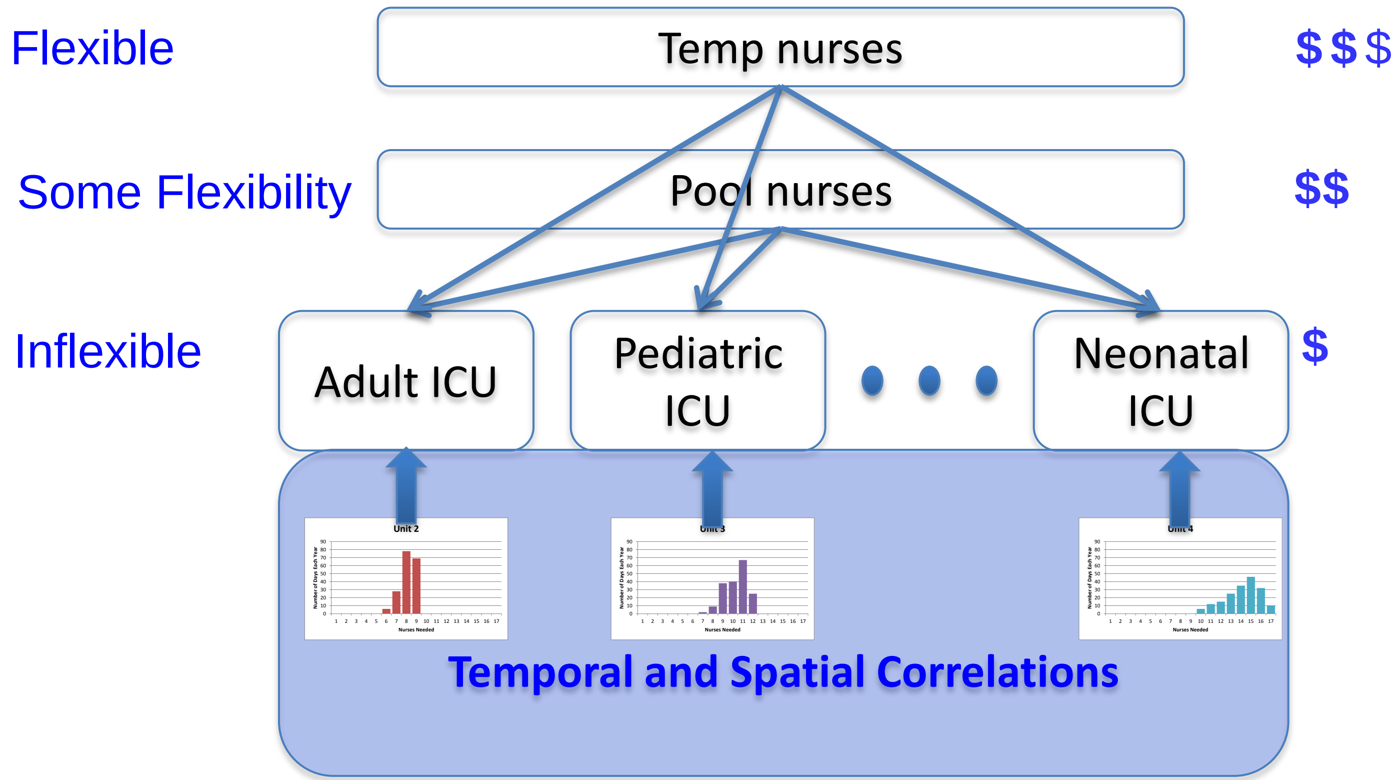
Key Issue





High variability in census needs and nursing availability

How is nursing organized at UMHS



Absenteeism

- Nurses may not be able to provide care for patients due to:
  - Not being at work:
    - Paid Time Off
    - Unpaid Time Off
    - Conferences/Employee Development
  - Being at work:
    - Educational Commitments
    - Administrative Responsibilities

20% at UMHS

Goal

Determine UMHS nurse staffing levels to:

- Ensure patient demand is satisfied
- Minimize nurse staffing costs

While accounting for uncertain:

- Demand
- Nurse Absenteeism

Formulation: Sets

$\boldsymbol{J}$ Units in a pool

$\boldsymbol{S}$ Demand scenarios

$\boldsymbol{R_s}$ Realizations of absent nurses in scenario $s \in S$

Formulation: Parameters

Daily cost per nurse

- c_j unit $j \in J$
- d pool
- e temp.

Value of extra nurse: f

Probability

- q_s of demand scenario
- θ_s^r of absenteeism realization

# of nurses needed in unit $j \in J$ in scenario $s \in S$: η_{js}

# of absent nurses in realization $r \in R_s$ from:

- a_{js}^r unit $j \in J$
- b_s^r pool

Formulation: Decision Variables

Long Term Decisions:

of nurses to hire:

- $\boldsymbol{X_j}$ unit $j \in J$
- $\boldsymbol{Y}$ pool

Daily Decisions:

For unit $j \in J$, scenario $s \in S$, realization $r \in R_s$

- $\boldsymbol{Z_{js}^r}$ # of pool nurses to allocate
- $\boldsymbol{W_{js}^r}$ # temp nurses to hire
- $\boldsymbol{V_{js}^r}$ # of extra nurses

Model Formulation

Min $$\sum_{j\in J} c_j X_j + dY + \sum_{s\in S} q_s \sum_{r\in R_s} \theta^r \left\{ e \sum_{j\in J} W_{js}^r - f \sum_{j\in J} V_{js}^r \right\}$$

Unit + pool + E{Temp – Extra} Cost

Subject to:

$$X_j - a_{js}^r + Z_{js}^r + W_{js}^r - V_{js}^r \geq n_{js} \; \forall\, j \in J; \; s \in S; \; r \in R_s$$

Unit – Unit Absenteeism + Pool Assignment + Temp – Extra ≥ Needed

$$\sum_{j \in J} Z_{js}^r + b_s^r = Y \qquad \forall\, s \in S; \; r \in R_s$$

All pool nurses are either assigned to a unit or absent

Integrality and Non-Negativity Constraints

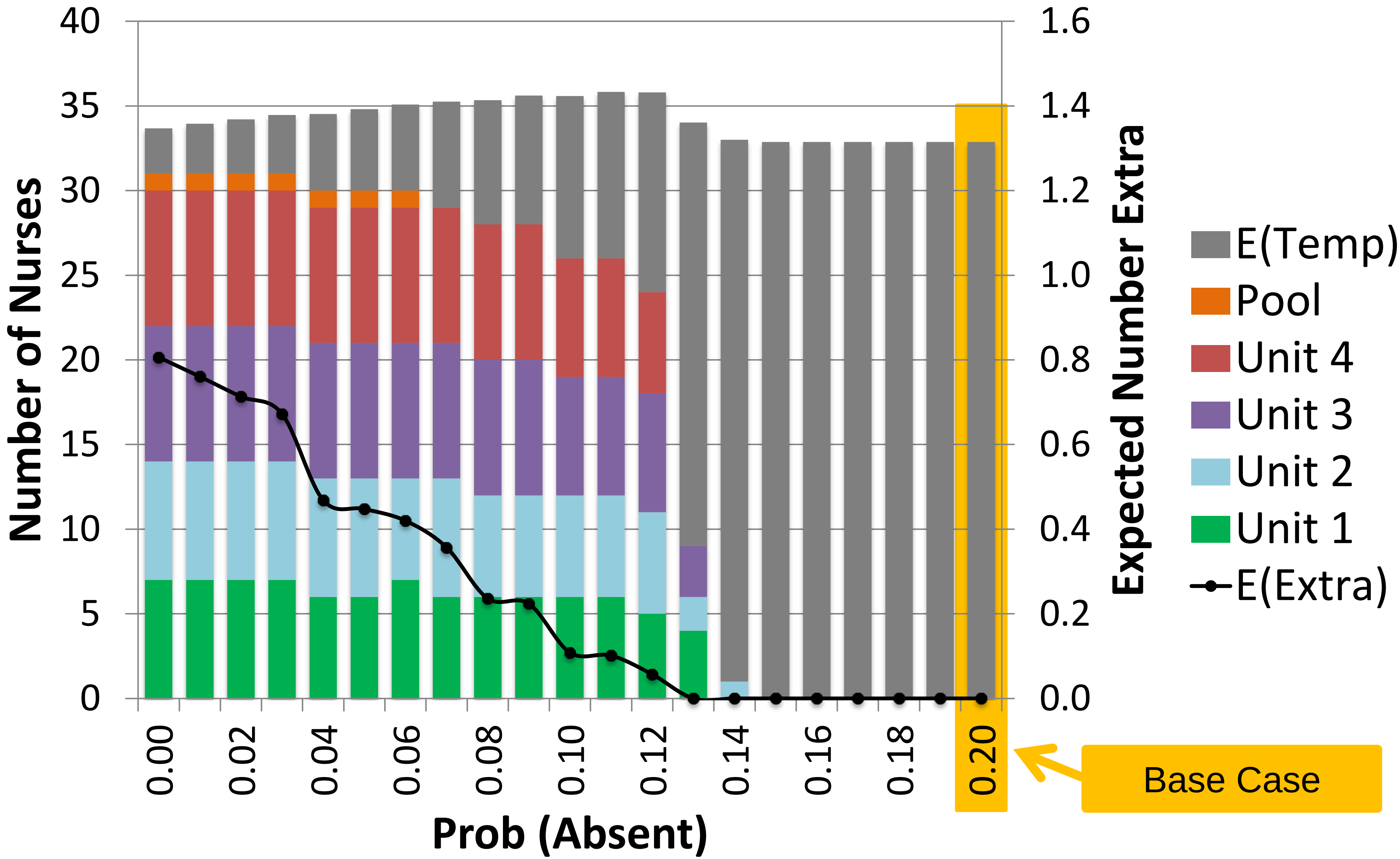
Example Results

- 4 Unit Pediatric Acute Care Pool
- 366 days in 2012

	Cost	P(Absent)
Unit	$400	0.2
Pool	$425	0.2
Temp	$460	0
Extra	$200	

Genetic Algorithm Parameters	Value
Pop. Size	25
Max Generations	100,000
Max Generations w/out an improvement in the pop.	20,000
P(Mutation)	0.25
Reps/day	20

Sensitivity to P(Absent)

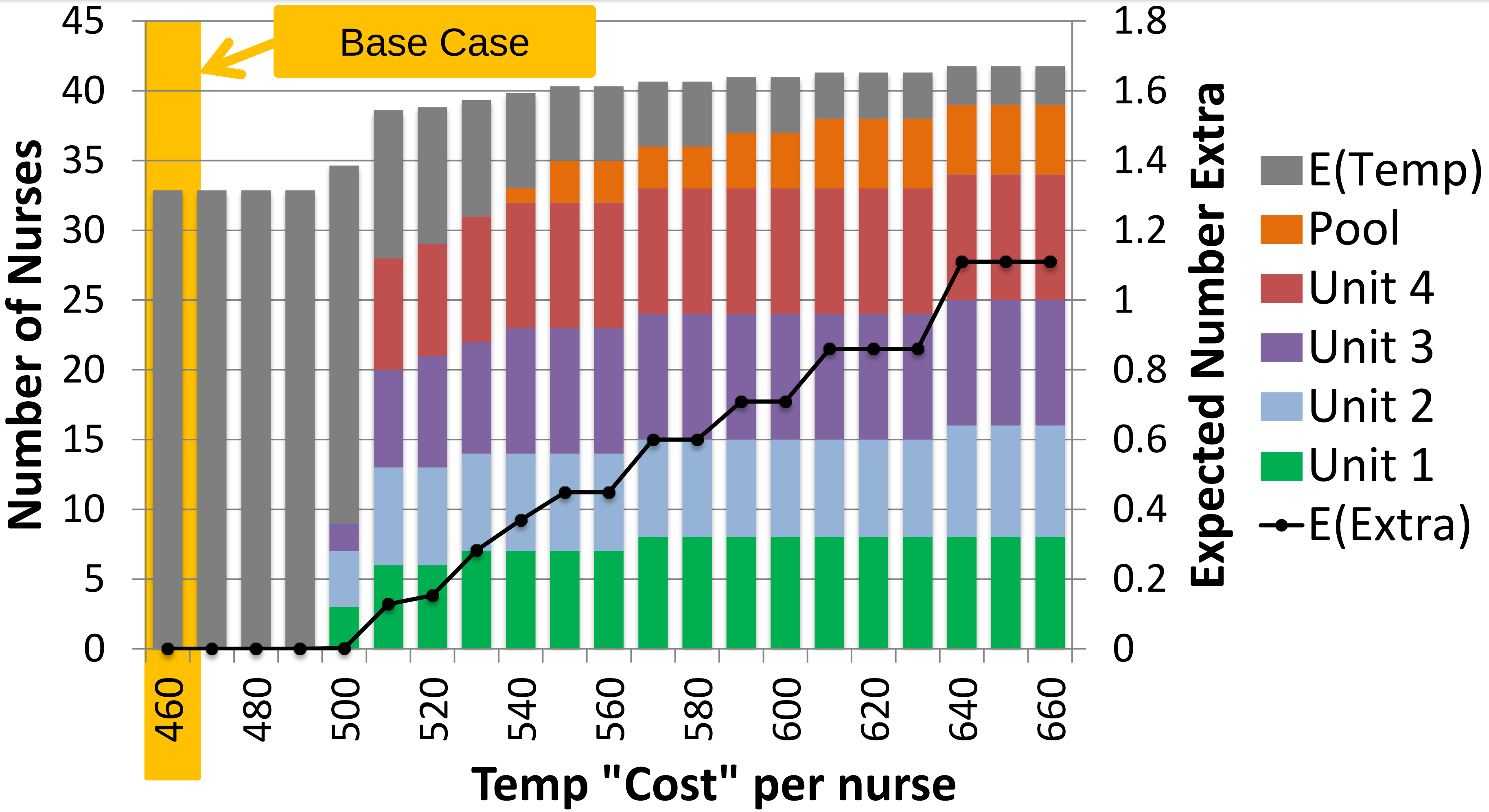


Why Does This Happen?

	Nominal Cost	P(Absent)	Cost/Contact Day
Unit	$400	0.2	$500
Pool	$425	0.2	$531.25
Temp	$460	0.0	$460

Unit and Pool nurses more $ per contact hour
Why use them?

… But Temp Nurses Are Not As Good



- **Use UNIT w/ 8.7% temp penalty**
- **Use POOL w/ 17% temp penalty**

Chance Constraint

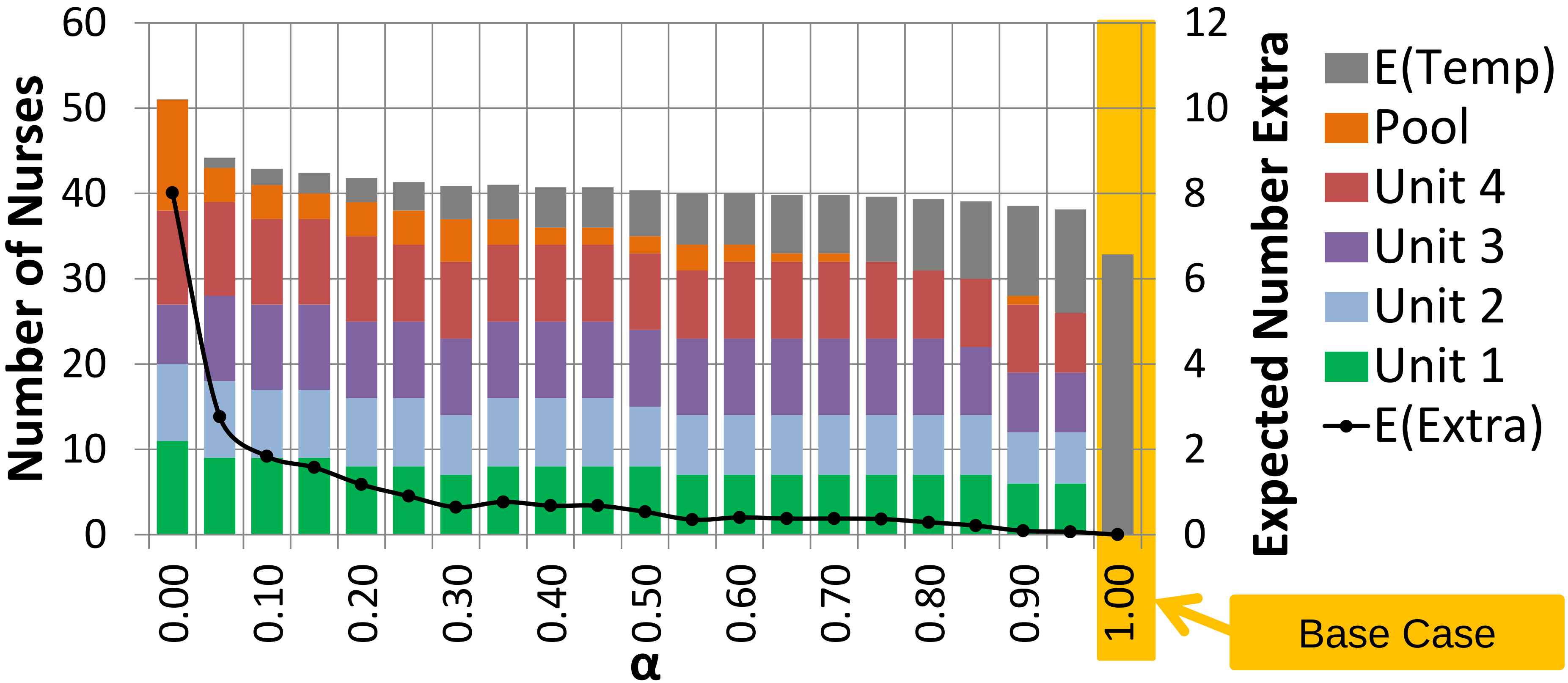
<u>Limit on the # of temp nurses that can be hired</u>

$$P\left(\sum_{j\in J} W_{js}^{r} > \tau; \forall s \in S; r \in R_s\right) \leq \alpha$$

P(use more than τ temps in any realization)$\leq \alpha$

Chance Constraint Results

P(5 or more temp nurses needed) ≤ α



- No employees hired when Prob=1
- More hired as Prob goes down

Conclusions

- With current staffing costs and absenteeism rates, the “cost minimizing” solution does not use hospital based nurses.
- Hospital based nurses are used if
  - Penalty using temps is $\geq$8.7%
  - Absenteeism rate $\leq$70% its current rate
  - Account for limited availability of temp nurses

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Thank You!