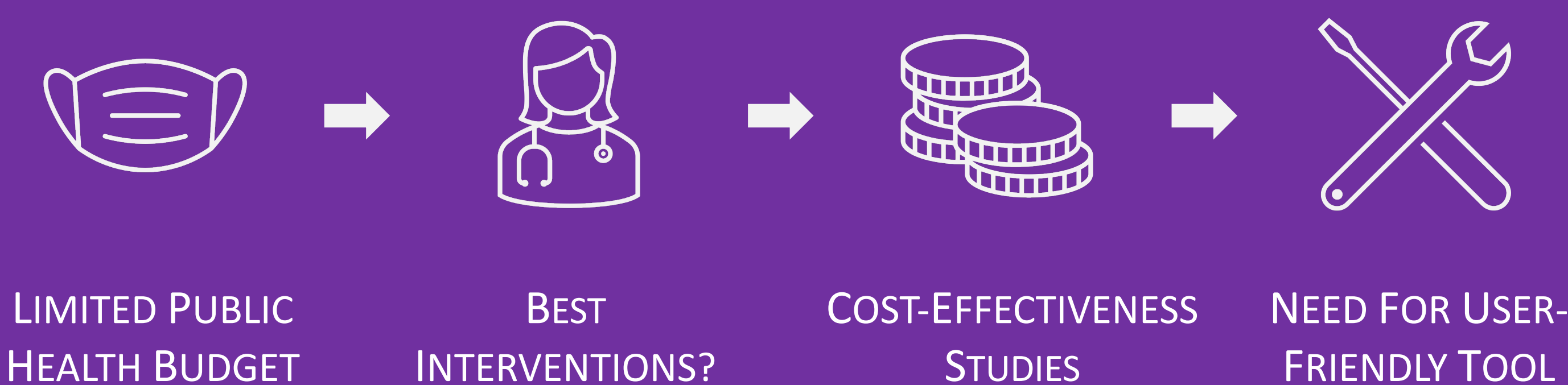


Predictive Modeling for Decision-making in Public Health

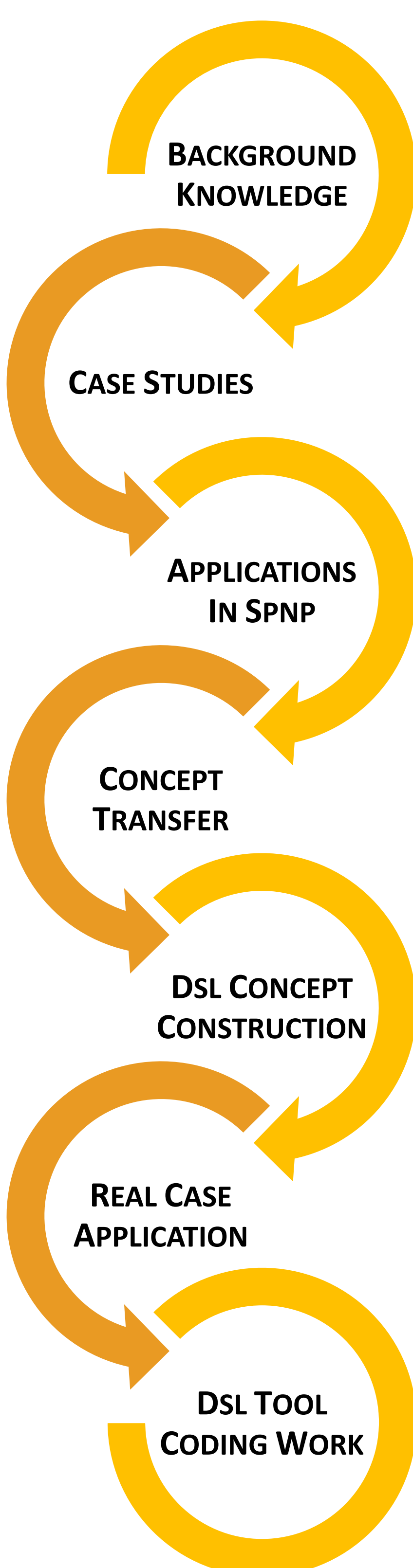
RESEARCH BACKGROUND



AIMS OF OUR BASS TEAM

- **MAIN OBJECTIVE:** provide public health practitioners and policy makers with a user-friendly tool supporting Cost-Effectiveness Analysis (CEA) THROUGH
- **INTERDISCIPLINARY RESEARCH:** join efforts from computer engineering, global health and public policy, from Duke and from DKU FOR DESIGNING
- **A DOMAIN SPECIFIC LANGUAGE:** specify and execute CEA, using a solid modeling formalism called Stochastic Reward Nets (SRNs)

PROJECT ACTIVITIES



- Group-study on CEA and SRNs**
- Made learning materials for CEA method
 - Developed simplified how-to for SPNP tool

- Literature review on CEA papers**
- Conducted case study on papers using CEA
 - Translated the model from DTMC into SRN

- Practice using SPNP**
- Replicated the paper using SPNP tool
 - Compared the results with the original one

- Mapping CEA into SPNP**
- Broke down CEA into separate steps
 - Linked the steps with features of SPNP

- Design on DSL**
- Identified concepts to define in DSL
 - Listed attributes for each concept from CEA

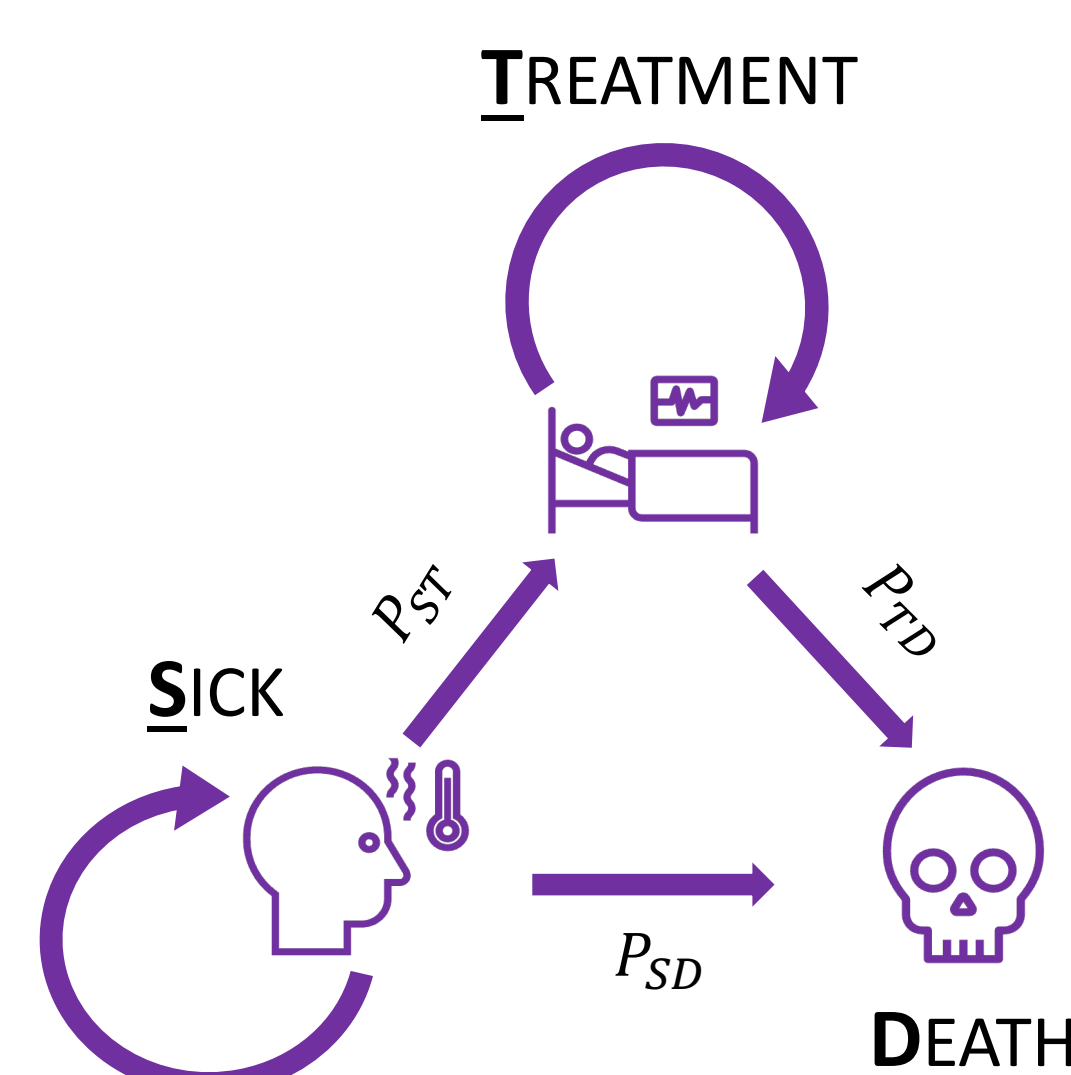
- Test on real cases**
- Conducted literature review on CEA papers
 - Fitted the existing research with our DSL

- To-do: Code into DSL**
- Program the DSL based on SPNP tool
 - Test and improve using more cases

COST EFFECTIVE ANALYSIS (CEA)

USING MARKOV CHAIN MODELLING

A simplified example to compare T_1, T_2, T_3 :



Transition Probability Matrix:

$$\begin{matrix} & S & T & D \\ \begin{matrix} S \\ T \\ D \end{matrix} & \begin{bmatrix} 1 - p_{SD} - p_{ST} & p_{ST} & p_{SD} \\ 0 & 1 - p_{TD} & p_{TD} \\ 0 & 0 & 1 \end{bmatrix} & &
 \end{matrix}$$

	COST (\$)	BENEFIT (QALYs)
S	C_S	B_S
T	C_T	B_T
D	C_D	B_D

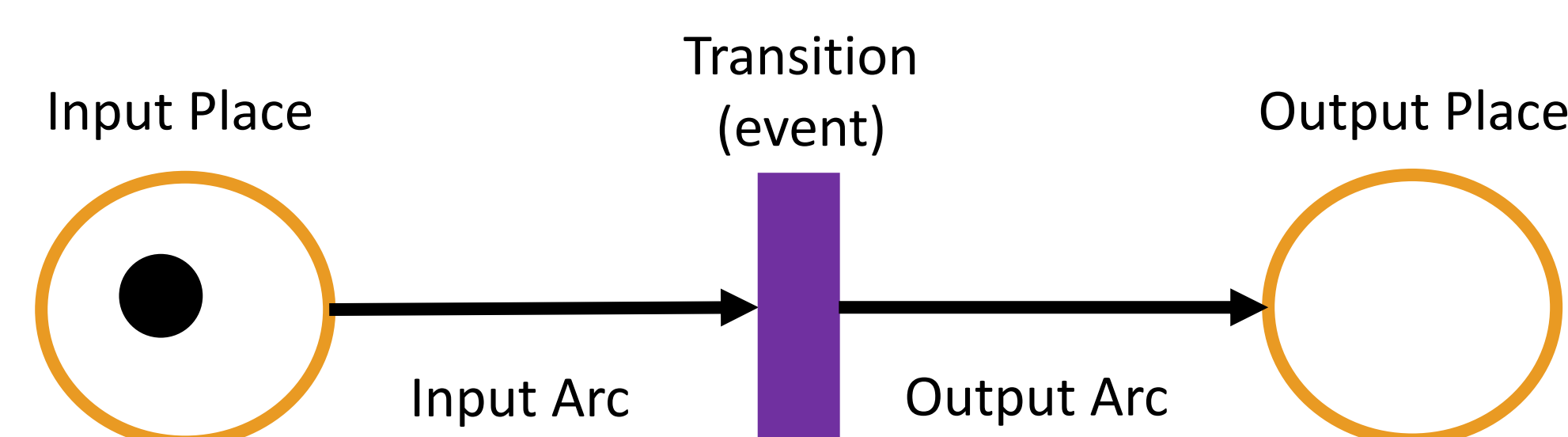
With calculated probability matrices, we can generate the output table for different interventions T_1, T_2, T_3 like below:

Treatment	Cost (\$)	Effectiveness	Incremental cost per QALY gained
T_1	C_1	E_1	Reference group
T_2	C_2	E_2	$\frac{C_2 - C_1}{E_2 - E_1}$
T_3	C_3	E_3	$\frac{C_3 - C_1}{E_3 - E_1}$

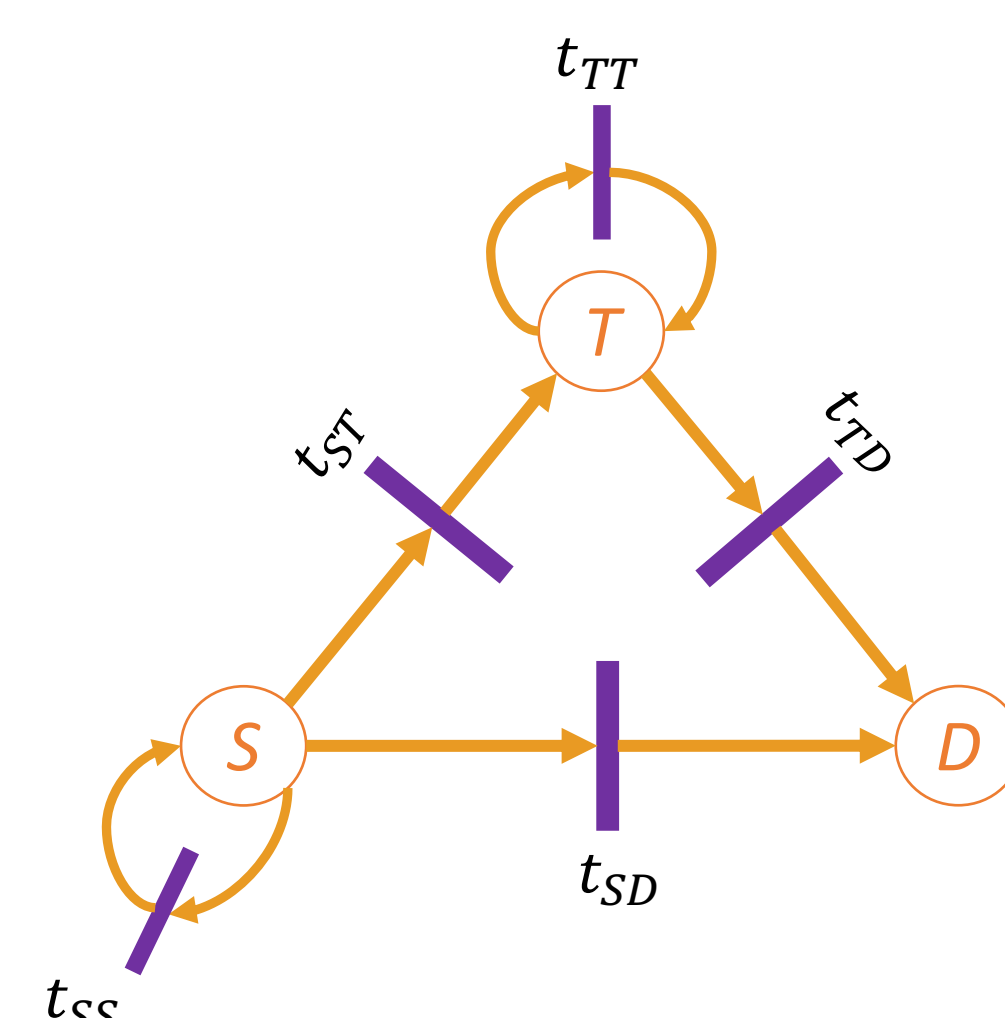
STOCHASTIC REWARD NETS (SRNs)

OUR CHOICE FOR PREDICTIVE MODELING

Basic Components of SRN models:



Translate the above model to SRN:



ADVANTAGES OF SRNs

- ✓ Better abstraction, closer to the domain than Markov chains
- ✓ Easier to define models for large and complex systems
- ✓ Easier to solve analytically
- ✓ Natively incorporate the concepts of costs and benefits
- ✓ Able to study the dynamic behavior of the system
- ✓ SPNP tool available from Duke

DOMAIN SPECIFIC LANGUAGE (DSL)

HIDING COMPLEXITY: A LANGUAGE TAILORED TO CEA STUDIES

> STUDY OVERVIEW

- **Purpose:** provide a summary description of the study
- **Attributes:** References, Main objective, Perspective, Place, Time horizon, Discount rate

> CONDITION

- **Purpose:** define the health issue object of the study, the health states of individuals and possible evolutions
- **Attributes:** Name, Health states, Transition, Revision Period

> INDIVIDUALS

- **Purpose:** define the characteristics of individuals in the study
- **Attributes:** Number, Genders, Ages...

> GROUPS

- **Purpose:** define sub-groups to provide shorthand notation
- **Attributes:** Group name, Composition

> INITIAL CONDITIONS

- **Purpose:** assign individuals to health states at time $t = 0$
- **Attributes:** Group names, number, percentages

> INTERVENTION

- **Purpose:** define actions aimed at improving the condition of patients
- **Attributes:** Name, Treatment, Subjects, Period, Cost, Value

> COST

- **Purpose:** name cost elements defined by users, assign monetary values and specify the frequency of cost accrual
- **Attributes:** Name, Amount, Accrued

> UTILITIES & BENEFITS

- **Purpose:** assign value of intervention effects to each state
- **Attributes:** Name, On state, Value, Accrued

> METRICS

- **Purpose:** define quantities to be evaluated
- **Attributes:** Name, Evaluation Rules, such as:
 - accumulate <quantity> on <health states> for <treatment>
 - count <health states> for <treatment>

> ANALYSIS

- **Purpose:** specify the parameter for sensitivity analysis
- **Attributes:** Name, Parameters, Metric, Algorithm

> REPORT

- **Purpose:** specify the output to be generated
- **Attributes:** Metrics, Analysis, Formats = table/line/histogram/bars

DEFINITION OF KEY CONCEPTS

- ❖ **Cost-Effectiveness Analysis (CEA):** a formalized process to comparatively evaluate both the costs and outcomes of candidate health interventions
- ❖ **Stochastic Reward Nets (SRN):** a probabilistic modeling formalism supporting definition of structural and timing behavior of the system, as well as the specification of the measures to be computed
- ❖ **Stochastic Petri Net Package (SPNP):** Tool developed by Prof. Trivedi to define and analyze SRN models
- ❖ **Domain Specific Language (DSL):** Computer language specialized to a particular application domain