

Modelling Provider Knowledge Skills and Abilities (KSA)

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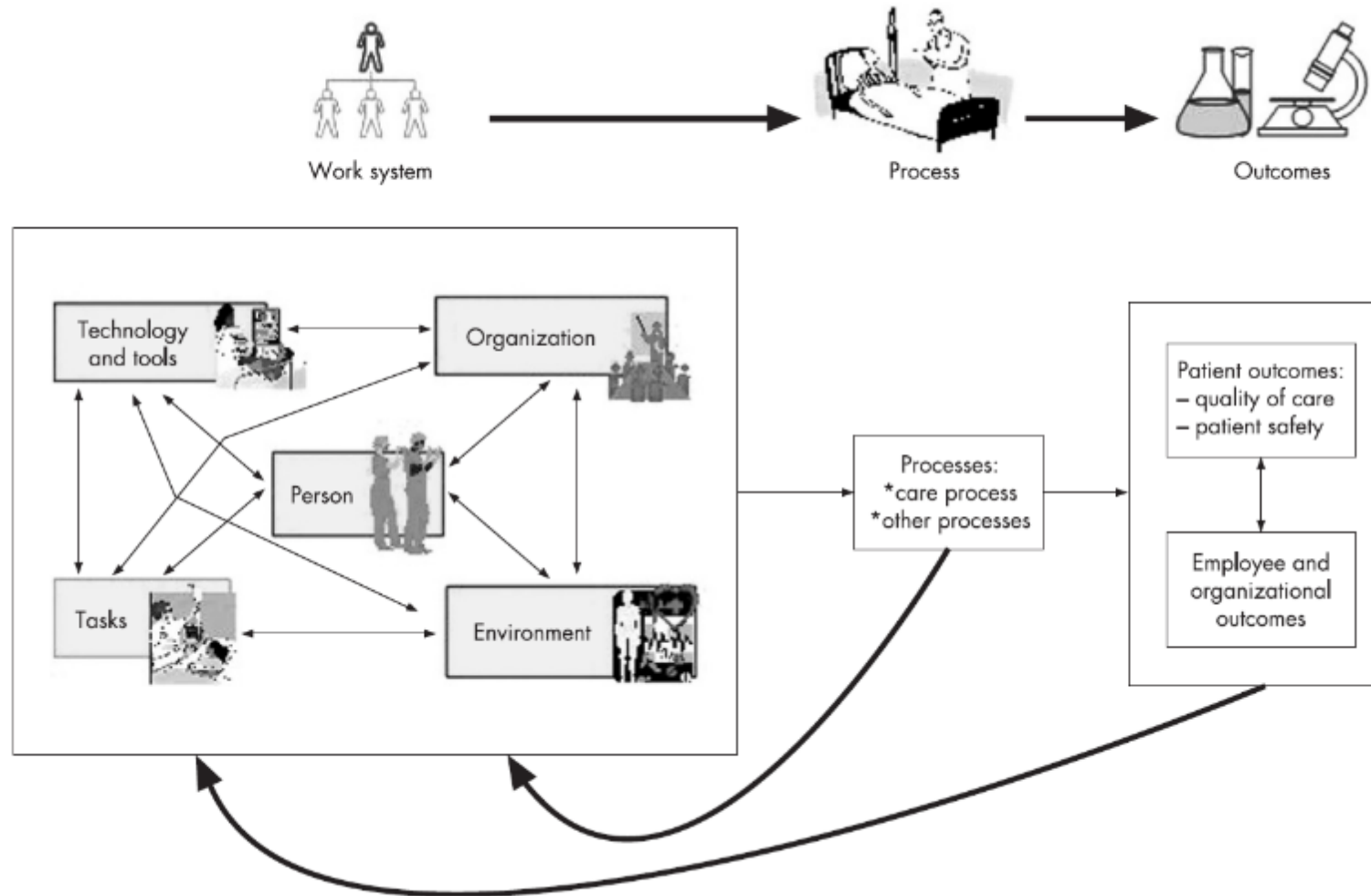
Kerry McGuire, PhD

Human Research Program

Exploration Medical Capability Element

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“Expanding the Boundaries of Space Medicine and Technology”



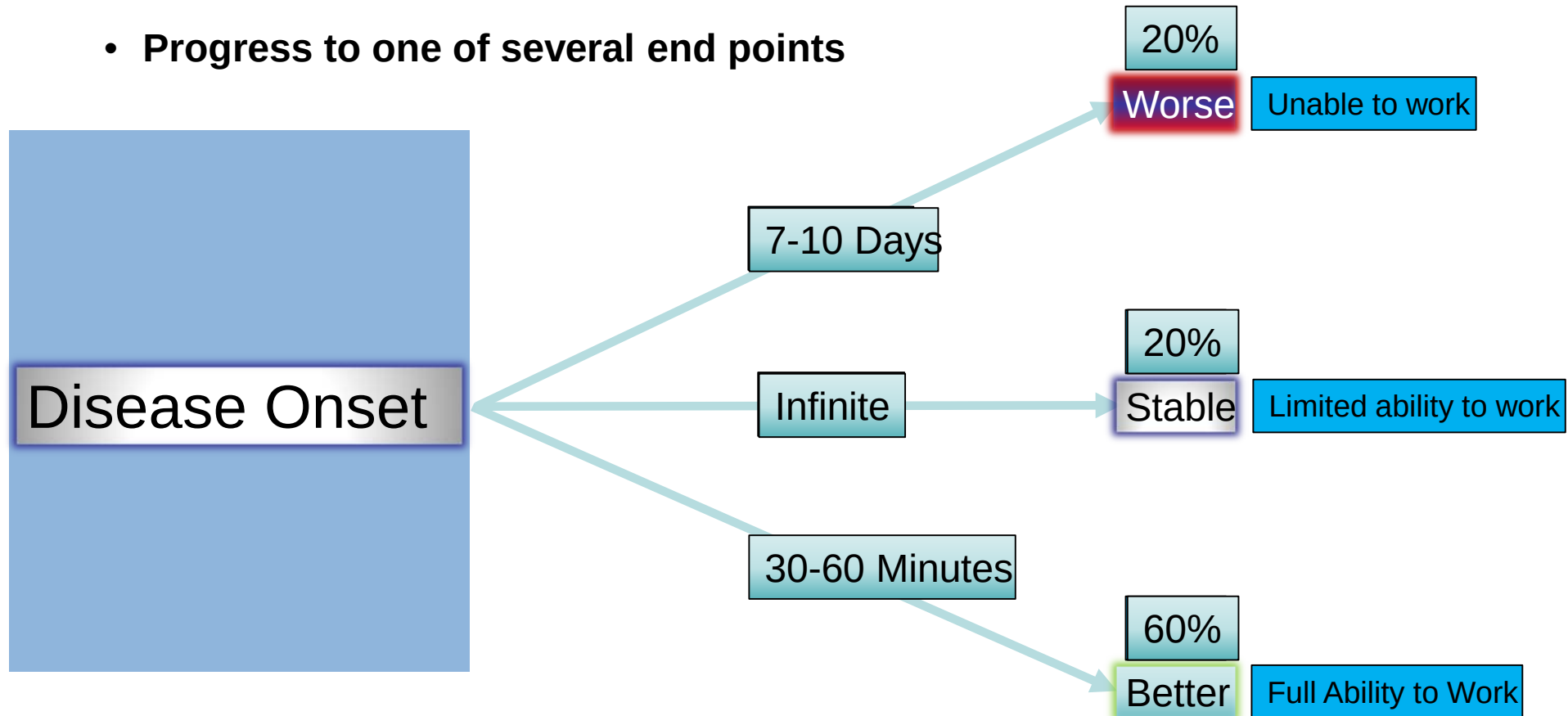
Carayon et al., 2006

- This is a conceptual approach that is in progress
- Care systems depend on care providers
- Most sophisticated hospital staffed by coffee baristas
- Best trained care team on a deserted island
- We need both

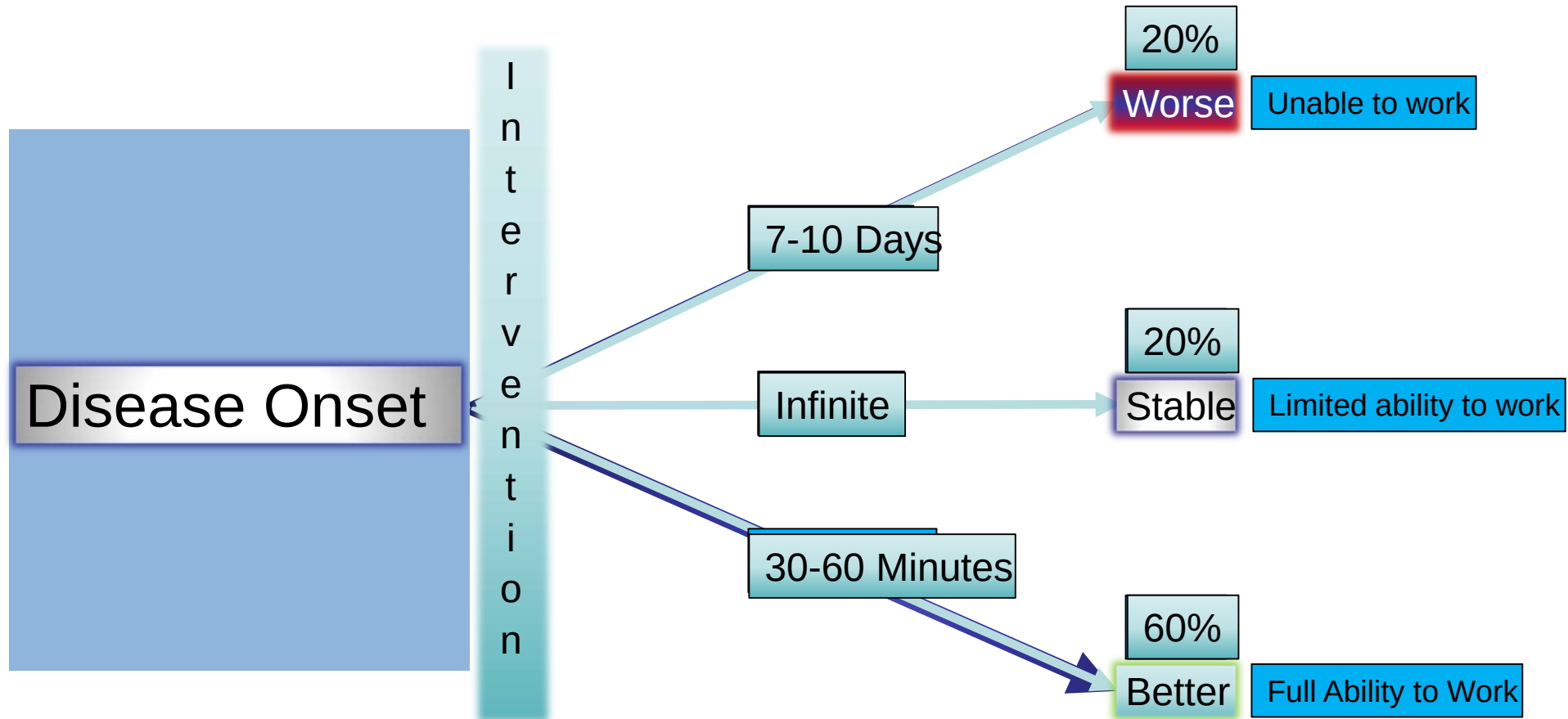


- **Qualitative:**
 - EMT, Paramedic, Nurse, Doctor, Specialist, Subspecialist
- **Minimum training level based on standards**
- **Doctor $\neq$ Emergency Physician $\neq$ Psychiatrist**
- **Quantitative: ?**

- One way is to start with how attributes of each provider affect aspects of disease progression
- Diseases start with an initial insult or defect
- Progress to one of several end points

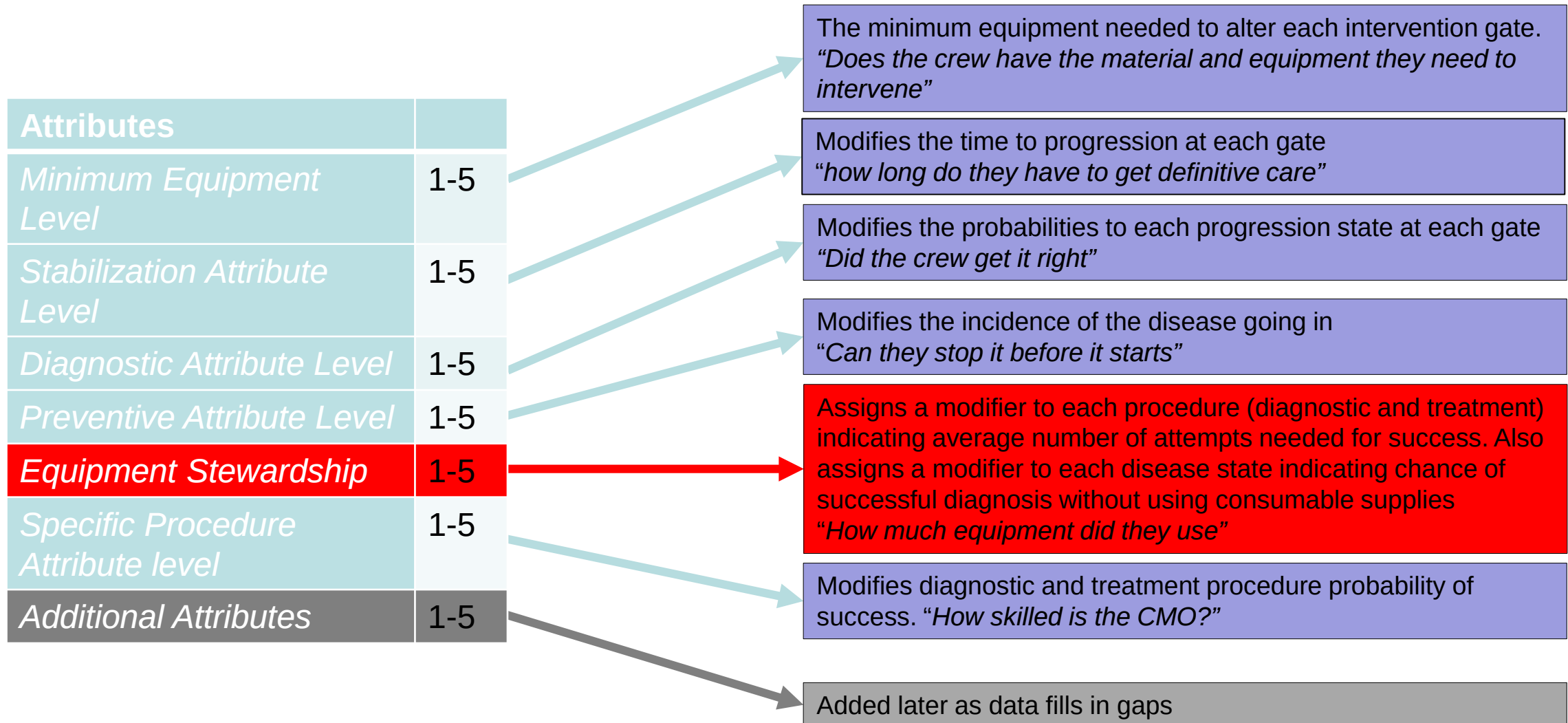


- **Medical intervention alters;**
 - The probability of disease progression: Curative
 - The time to progression: Stability
 - Severity of Symptoms: Palliative

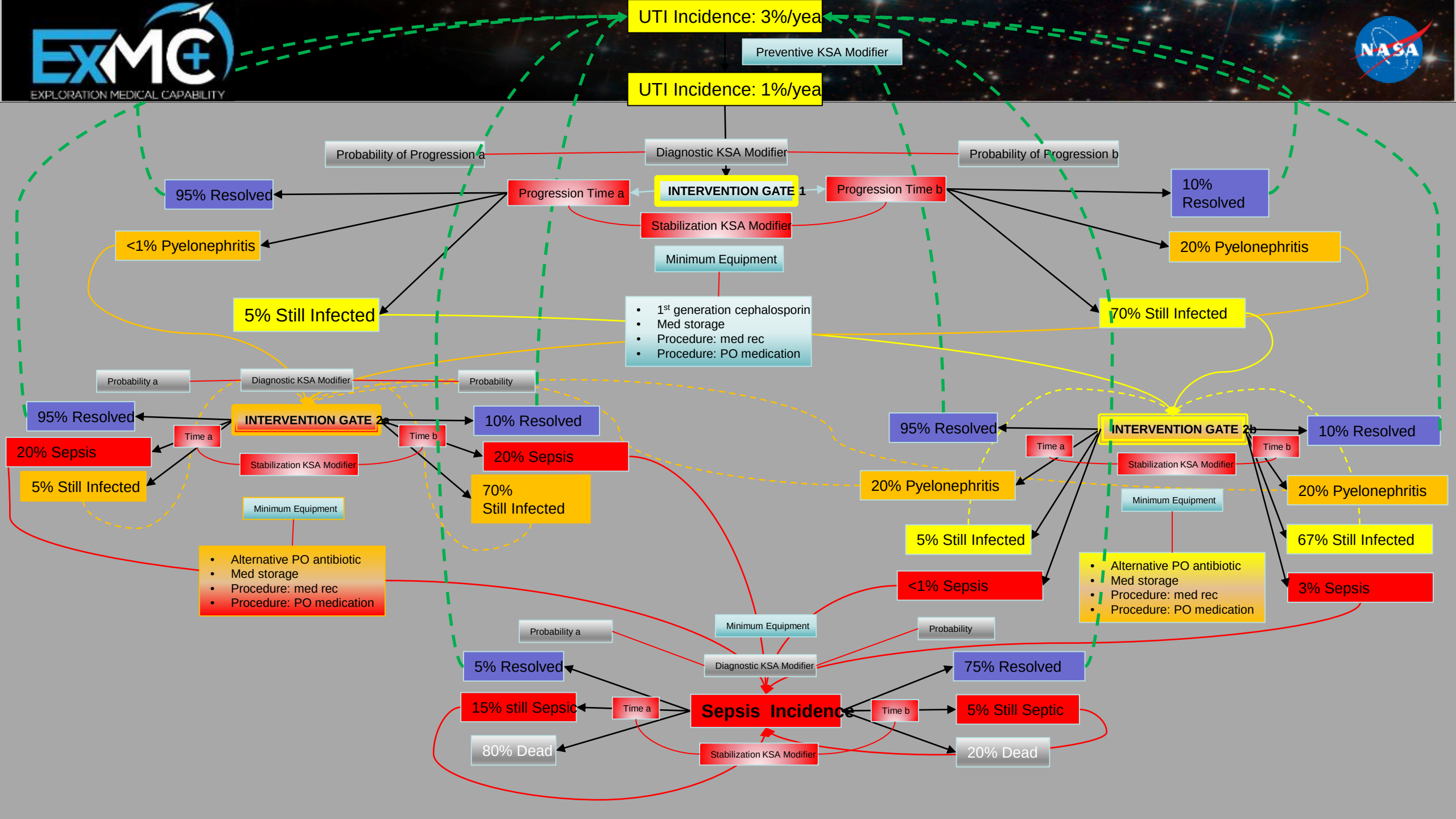


- **The probability of an intervention being successful depends on;**
 - Diagnosis
 - Clinical data
 - Lab data
 - Imaging data
 - Stabilization
 - Palliation
 - Repair/Healing/curative
- **This may provide the basis for how KSAs can be integrated into a model system**

- Specific providers can be modelled with “Attribute Points”



- Each provider training level represents varied amounts of skill in specific areas



Data

Do We Know Enough?

- If we have a list of diseases, we can cull the literature to see what data is out there, rate the quality of the data, and identify where there are gaps that we need to fill with new research/determine if this gap filling is worth the investment.

Time required

	Days
Incidence	1
Natural history flowchart	2
Natural history data collection	7
Diagnostics	2
Impact of practitioner on diagnostics	1
Treatments	1
Review, refinement	1
Total	~15

Do We Know Enough?: Example Data Search

Main sequence		Alternate paths			
0 Naive					
↓					
1 Asymptomatic nephrolithiasis	→	1b Painless stone passage			
		1c Silent hydronephrosis [SKIP TO 5]			
↓					
2 Symptomatic stone passage	→	2b Atypical pain, non-pain symptoms, or hematuria-only [SKIP TO 4]			
	→	2[+] Concurrent positive urine culture [CONTINUE]			
↓					
3 Painful colic	→	3b Misdiagnosis of non-stone disease as renal colic*			
↓					
4 Waiting period	→	4b Spontaneous passage			
	→	4c Persistent, nonobstructing stone**			
↓					
5 Persistent, obstructing stone	→	5b Obstructive nephropathy	→	5b(1)	Unilateral renal failure injury and failure
	→	5c Ruptured calyx with urinoma			
↓					
6 Upper UTI	→	6b Spontaneous passage			
	→	6c Responsive to antibiotics [GO TO 4]			
	→	6d Persistent without sepsis	→	6d(1)	Abscess formation, pyonephrosis, or XGP
	→	6e Antibiotics unavailable	→	6e(1)	Sepsis [GO TO 7]
			→	6e(2)	Abscess formation, pyonephrosis, or XGP [GO TO 6c(1)]
			→	6e(3)	Spontaneous resolution [GO TO 4]
↓					
7 Sepsis	→	7b Responsive to antibiotics			
↓					
8 Septic shock	→	8b Responsive to treatment			
	→	8c Mortality			

Do We Know Enough?: Example Data Search

	<i>Incidence/yr</i>	<i>n</i>	<i>Date range</i>	<i>Location</i>	<i>Sex</i>	<i>Age</i>	<i>Only First Stones</i>	<i>Citation</i>	<i>Comment</i>
	0.20%	468	1965-1974	Minnesota	Males	35-49	Yes	5	Close to true incidence (retrospective, complete population data)
	0.05%	204	1950-1974	Minnesota	Females	35-49	Yes	5	Close to true incidence (retrospective, complete population data)
	0.24%	157	1970-2000	Minnesota	Males	40-49	Yes	8	Close to true incidence (retrospective, complete population data)
	0.08%	91	1970-2000	Minnesota	Females	40-49	Yes	8	Close to true incidence (retrospective, complete population data)
	0.33%	121	1986-1990	US	Males	<45	Yes	6	True incidence (prospective survey)
	0.38%	92	1986-1990	US	Males	45-49	Yes	6	True incidence (prospective survey)
	0.31%	77	1986-1990	US	Males	50-54	Yes	6	True incidence (prospective survey)
	1.90%	12	1998	Seoul, Korea	Males	40-79	No	7	Point prevalence w/in 1 year, not incidence
	0.30%	4	1998	Seoul, Korea	Females	40-79	No	7	Point prevalence w/in 1 year, not incidence
	0.25%	54	2006-2012	Sweden	Men	20-39	Yes	9	From a control cohort w/o gout (sup. data)
	0.36%	402	2006-2012	Sweden	Men	40-59	Yes	9	From a control cohort w/o gout (sup. data)
	0.28%	15	2006-2012	Sweden	Women	20-39	Yes	9	From a control cohort w/o gout (sup. data)
	0.17%	52	2006-2012	Sweden	Women	40-59	Yes	9	From a control cohort w/o gout (sup. data)
	0.15%	*	-	US Navy - Pacific	Both	-	No	30	Based on: US Navy After-Action Reports, 5-12 cases per deploy of 5000-6000 crew
<i>Mean ± SD (M)</i>	0.60% ± 0.73%								
<i>Mean ± SD (F)</i>	0.16% ± 0.12%								
<i>Mean ± SD (all)</i>	0.38% ± 0.54%								Note: example data, not a meta-analysis!

Do We Know Enough?: Example Data Search

6 > 8	In a smaller study, the rate of severe sepsis associated with stone-related pyelonephritis was 12.5% [citation 36].
	In another, the rate of septic shock associated with stone-related pyelonephritis was 33%. [citation 33]
	The rate of severe sepsis associated with all infected urolithiasis was 3.2% in a nationwide inpatient sample. [citation 32]
7 > 7b	Unable to find data, however, this is equal to the complement of 7 > 8.
7 > 8	Unable to find data.
7 > 8b	This statistic may be derived as the complement of the mortality, or 100-19% = 81% [citation 28].
6 > 8c	The mortality rate of obstructive pyelonephritis due to stones, in the subset whose initial drainage trial failed, was 5.6% (vs 2.5% where drainage succeeded). [citation 43]
	The mortality rate was 1.1% in those who never were drained (these cases were in too dire condition for drainage) [citation 43].
	However, as drainage was always available and used according to the patient's severity, these statistics do not reflect the natural history.
	The more useful number may be the percentage who were drained, 67%. [43] This reflects the portion for whom drainage was indicated, and likely necessary.
	In another study, those with obstructive pyelonephritis (with fever) due to calculi who did not undergo drainage had 100% survival. [citation 31]
	In another, those with obstructive pyelonephritis due to calculi had 8% mortality [citation 37].
	Again, these disparate numbers reflect a selection bias of patients deemed to require drainage.
	The mortality rate from infected urolithiasis was 0.2% - 0.25% in a nationwide inpatient sample. [citation 32].
7 > 8c	19.2% of septic stone patients not undergoing surgical decompression died. [citation 28]
	The mortality rate of obstructive pyelonephritis patients with qSOFA score 2 or greater was 18%. [citation 37]
8 > 8c	The mortality rate from stone-related severe sepsis was 27% - 40% in a nationwide inpatient sample. [citation 32].
	The mortality rates of those with obstructive pyelonephritis due to calculi with SOFA score 7 or greater was 28%. [citation 37]

Effect of diagnostics on progression

<i>Procedure</i>	<i>Notes / Data</i>	<i>Natural history nodes modified</i>	<i>Citation</i>
History and Physical	The most significant predictors of renal colic were hematuria, short duration of pain (<12h), loin or renal tenderness, normal appetite.	3>3b	45
Urinalysis	The presence of hematuria has 85% sensitivity for renal stone.	3>3a	11
	The presence of pyuria gives a 36% chance of positive urine culture, versus 3% without. Large, medium and small/none leukocyte esterase correlated with chance of infection (78% vs 41% vs 2%).	2 > 2+	21
CBC	Elevated WBC count was not associated with UTI in renal colic.	2 > 2+	29
BMP	The presence of acute kidney injury may be due to obstructive nephropathy, but this has a poor NPV, as the contralateral kidney compensates so that creatinine does not rise.		
	The prevalence of AKI in the setting of ureteral stones was 0.72%; of these 47% had a solitary kidney and 33% had bilateral stones.		39
Ultrasound	A totally negative sonogram predicts a very low need for urologic intervention. This can be seen as a surrogate for the presence of obstruction or severe medical complication. (0% - 3.5% (95% CI) risk for intervention if negative)	4>5	10
	Pooled sensitivity and specificity of 45% and 94% for ureteral calculi. New stone-specific ultrasound modes improve this performance.		46
			46
Doppler ultrasound	The delta resistive index was 81% sensitive and 96% specific for obstruction.	4>5	47
	Ureteral jet peak velocity above 15.25 cm/s had 85% sensitivity and 63% specificity for spontaneous passage within 4 weeks.	4>4b	49
KUB X-ray	Sensitivity of 37% for stones <5mm, 88% for stones >5mm. Thus, useful in excluding stones that may not pass spontaneously.	4>4b	46

Effect of treatments on progression

<i>Treatment</i>	<i>Notes</i>	<i>Natural history point(s) modified</i>	<i>Citation</i>
Tamsulosin	By meta-analysis, absolute risk reduction of 22% for non-passage of distal stones 5-10mm; however, many studies have null result. Given the heterogeneity of results, tamsulosin would not add much value to risk calculations; nonetheless, as it is widely used and favored, it may be prudent to consider it as a "bonus" medication.	4>5	12
Extracorporeal shockwave lithotripsy	Emergency ESWL has strong results in renal colic. However, technology and technique would differ significantly from terrestrial evidence. Analysis has shown ESWL failure predicted by stone burden, previous ipsilateral calculi.		51
	Early ESWL for a mean stone size of 7mm produced 89% fragmentation, 86% 3 month stone free rate, and 10 day mean stone clearance.	4>5	53
	Early ESWL for a mean stone size of 10mm produced 53% stone-free at 24 hours, 79% at 3 months.	4>5	52
Antibiotics	Data not found on non-use of antibiotics.		
Percutaneous nephrostomy	Surgical decompression in sepsis due to stone is associated with 8.9% mortality versus 19% mortality (p<.001).	7>8c	28

Comparing Provider Types

- **Point-of-care Ultrasound with Radiology read Ultrasound**^[50]
 - ER physicians (US trained): 85% sensitivity and 50% specificity
 - Radiology ultrasound: 84% sensitivity and 53% specificity
 - Not Significant
- **Bedside ultrasound in the hands of novice residents vs. attendings** ^[54]
 - Attendings were 87% accurate,
 - Residents were 80% accurate
 - Not Significant
- **Number of exams until competency in detecting hydronephrosis** ^[55]
 - 11-20 exams: Negative Predictive Value of 78%
 - 21-30 exams NPV of 93%
 - 31-43: NPV of 97%

- A system needs to fit the needs of the people operating it, training will vary so how do we design to accommodate individual needs
- Care systems depend on the provider's Knowledge Skill and Ability to operate them.
- In the Medical world title (EMT, Nurse, Doctor, etc...) is a proxy for KSA and represents a providers minimum level of training
- KSA needs to fit into a model of disease progression
- Disease progression can be modeled as the probability of a specific outcome and time to reach that outcome.
- KSA would modify factors that affect the outcome probabilities and the time to reach them.
- **One place to start is to define discrete categories of intervention**
 - such as; diagnosis, clinical data interpretation, stabilization interventions, palliation interventions, and repair/curative interventions.
- KSA's could be modelled as provider attributes reflecting these categories with "skill points" representing proficiency in each
- The qualitative titles can be modelled with these attribute points to build provider type or system augmentation profiles
- Such profiles would enable tradespace and risk analyses including KSA
- All of this relies on data to make it evidence based and until we collect this data, this remains conceptual
- Collecting this data will take time, and there are significant holes in the existing literature
- However, some work has already been done, and it is sufficient enough to show that this approach is workable
- This is a complex, interdisciplinary effort that must coordinate and integrate across all existing ExMC project groups, but the end result will help create a more accurate picture of medical mission risk to enable tradespace, risk, and pre/intra mission planning.

THANK YOU

Questions?