

ROOT CAUSE ANALYSIS OF THE DATA REFINEMENT PROCESS – MEDICAL CONDITIONS CAPABILITY RESOURCE TABLES

Human Research Program

Exploration Medical Capability Element

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Arian Anderson MD¹

Ali Al³

Dana Levin MD^{2,3}

David Hilmers MD^{4,5}

Lynn Boley³

**¹ University of Colorado School of Medicine; ² University of Texas Medical Branch ³KBR ⁴ Baylor
College of Medicine ⁵ TRISH**

“Expanding the Boundaries of Space Medicine and Technology”

- **Objective**
- **Background**
 - Capability Resource Tables (CRT)
 - Root Cause Analysis(RCA)
- **Error types**
- **RCA**
 - Fishbone; 5 whys
- **Lessons Learned**

- Review the development and import of CRTs into the Evidence Library (Ev Lib) to identify sources of error for improved data fidelity for future iterations and modifications

- Changing paradigm
 - Currently heavily ground dependent
- Earth Independent Medical Operations
 - Semi autonomous medical care
- Medical System Design?
 - Modeling

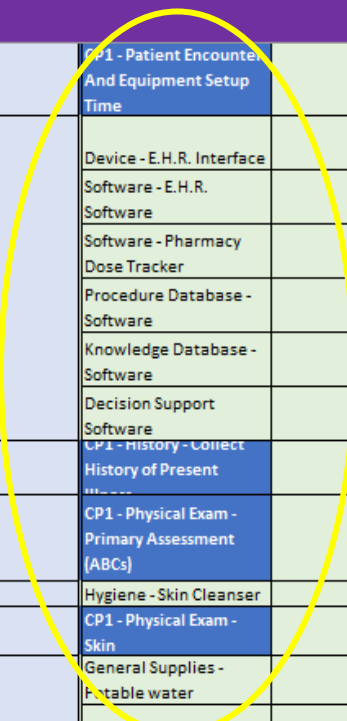
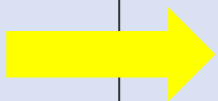
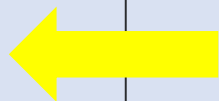
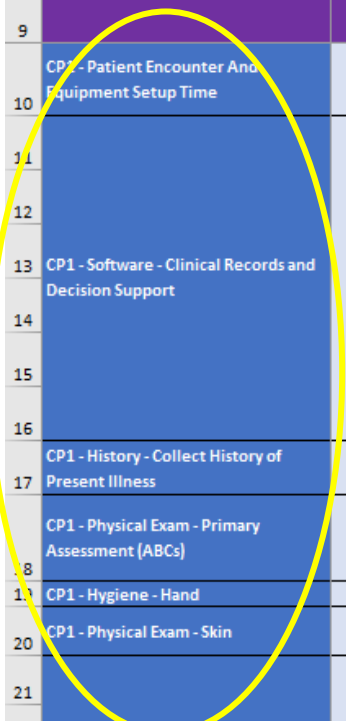
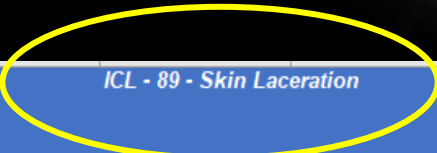


- Capability Resource Table
 - 120 Spaceflight Conditions
 - Best Case and Worst Case Scenarios
 - Resources required to treat
 - Number x duration
 - Alternate therapies
 - Skills required
 - Coded for IMPACT
 - Written in Excel
 - Consensus from 3 physicians

Capabilities Phase	Scope of Practice Code	Capability Category	Capability Class	Capability Contribution	Capability Necessity	Capability Equivalence	Capability Primacy	Capability Efficacy	Resource Phase	Resource Equivalent	Resource class	Resource Contribution
	<i>Definition: An uncomplicated, linear, laceration that is not under significant tension with minimal or no foreign body contamination that heals spontaneously or requires a single layer closure.</i>											
									Bundled Non-Alternate Cluster:		#	
									Bundled Non-Alternate Cluster:		#	0
									Alternate Cluster:		0	
CP1 - Physical Exam - Skin	4	Life Saving	Clinical	1	1	0	0	1	CP1 - Physical Exam - Skin		Clinical	1
CP1 - Physical Exam - Wound	4	Life Saving	Clinical	1	1	0	0	1	General Supplier - Potable water		Clinical	1
									Bundle - Wound Care Gauze		Clinical	1
CP1 - Physical Exam - Neurological - Focused Exam	4	Life Saving	Clinical	1	1	0	0	1	CP1 - Physical Exam - Neurological - Focused Exam		Clinical	1
CP1 - Interpretation - Physical Exam	4	Life Saving	Clinical	1	1	0	0	1	CP1 - Interpretation - Physical Exam		Clinical	1
									Device - E.H.R. Interface		Clinical	1
									Software - E.H.R. Software		Clinical	1
CP2 - Acute - Software - Clinical Records and Decision Support	1	Life Saving	Clinical	1	1	0	0	1	Software - Pharmacy Dose Tracker		Clinical	1
									Software - Medical Procedure Database - Software		Clinical	1
									Software - Medical Knowledge Database - Software		Clinical	1
CP2 - Acute - Management Decisions - Skin Laceration	4	Life Saving	Clinical	1	1	0	0	1	Software - Clinical Decision Support Software		Clinical	1
CP2 - PPE - Nitrile Gloves	1	Life Saving	Clinical	1	1	0	0	1	CP2 - Acute - Management Decisions - Skin Hygiene - PPE - Non Sterile Gloves		Clinical	1
									Bundle - Irrigation - Irrigation Solution		Pharmaceutical	1
CP2 - Procedure - Irrigate												

CRT Example

1	Best Case	ICL - 89 - Skin Laceration											
2		Definition: An uncomplicated, linear, laceration that is not under significant tension with minimal or no foreign body contamination that heals spontaneously or requires a single layer closure.											
3													
4													
5													
6	Capabilities Phase	Scope of Practice Code	Capability Category	Capability Class	Capability Contribution	Capability Necessity	Capability Equivalence	Capability Primacy	Capability Efficacy	Resource Phase	Resource Equivalent	Resource class	
7											Bundled Non-Alternate Cluster:		
8		Bundled Non-Alternate Cluster:			#	#	0	0	#	Alternate Cluster:			
9													
10	CP1 - Patient Encounter And Equipment Setup Time	1	Life Saving	Clinical	1	1	0	0	1	CP1 - Patient Encounter And Equipment Setup Time		Clinical	
11										Device - E.H.R. Interface		Clinical	
12										Software - E.H.R. Software		Clinical	
13	CP1 - Software - Clinical Records and Decision Support	1	Life Saving	Clinical	1	1	0	0	1	Software - Pharmacy Dose Tracker		Clinical	
14										Procedure Database - Software		Clinical	
15										Knowledge Database - Software		Clinical	
16										Decision Support Software		Clinical	
17	CP1 - History - Collect History of Present Illness	1	Life Saving	Clinical	1	1	0	0	1	CP1 - History - Collect History of Present Illness		Clinical	
18	CP1 - Physical Exam - Primary Assessment (ABCs)	1	Life Saving	Clinical	1	1	0	0	1	CP1 - Physical Exam - Primary Assessment (ABCs)			
19	CP1 - Hygiene - Hand	4	Life Saving	Clinical	1	1	0	0	1	Hygiene - Skin Cleanser		Clinical	
20	CP1 - Physical Exam - Skin	4	Life Saving	Clinical	1	1	0	0	1	CP1 - Physical Exam - Skin		Clinical	
21										General Supplies - Potable water		Clinical	



Capabilities Phase	ICL - 89 - Skin Laceration						
	<i>Definition:</i> An uncomplicated, linear, laceration that is not under significant tension with minimal or no foreign body contamination that spontaneously or requires a single layer closure.						
	Scope of Practice Code	Capability Category	Capability Class	Capability Contribution	Capability Necessity	Capability Equivalence	Capability Primacy
	Bundled Non-Alternate Cluster:			#	#	0	0
CP1 - Patient Encounter And Equipment Setup Time	1	Life Saving	Clinical	1	1	0	0
CP1 - Software - Clinical Records and Decision Support	1	Life Saving	Clinical	1	1	0	0
CP1 - History - Collect History of Present Illness	1	Life Saving	Clinical	1	1	0	0
CP1 - Physical Exam - Primary Assessment (ABCs)	1	Life Saving	Clinical	1	1	0	0
CP1 - Hygiene - Hand	4	Life Saving	Clinical	1	1	0	0
CP1 - Physical Exam - Skin	4	Life Saving	Clinical	1	1	0	0



Branches > Baseline > Medical Conditions > ICL89_Skin Laceration > Treatment Clusters

ICL89_Skin Laceration

Close

TREATMENT CLUSTERS

Name	Best Case							Worst Case						
	Contribution	Necessity	Equivalence	Rank	Efficacy	Frequency	Quantity	Contribution	Necessity	Equivalence	Rank	Efficacy	Frequency	Quantity
<ul style="list-style-type: none"> CP1 - History - Collect History of Present Illness Absolute CP1 - History - Collect History of Present Illness 	100	0	0	0	100	N/A		100	0	0	0	100	N/A	
<ul style="list-style-type: none"> CP1 - Interpretation - Physical Exam Absolute CP1 - Interpretation - Physical Exam 	100	0	0	0	100	N/A	1.00	100	100	0	0	100	Event	1.00
<ul style="list-style-type: none"> CP1 - Physical Exam - Neurological - Focused Exam Absolute CP1 - Physical Exam - Neurological - Focused Exam 	100	0	0	0	100	N/A	1.00	100	100	0	0	100	Event	1.00
<ul style="list-style-type: none"> CP1 - Physical Exam - Primary Assessment (ABCs) Absolute CP1 - Physical Exam - Primary Assessment (ABCs) 	100	0	0	0	100	N/A	1.00	100	100	0	0	100	Event	1.00
<ul style="list-style-type: none"> CP1 - Physical Exam - Skin Absolute CP1 - Physical Exam - Skin 	100	0	0	0	100	N/A	1.00	100	0	0	0	100	N/A	
<ul style="list-style-type: none"> CP1 - Physical Exam - Wound Absolute CP1 - Physical Exam - Wound 	100	0	0	0	100	N/A	1.00	100	0	0	0	100	N/A	
<ul style="list-style-type: none"> Bundle - Wound Care - Gauze - CORRECTED Absolute General Supplies - Clean Towel Wound Care - Dressing - 2x2 Gauze Square 	100	100	0	0	100	N/A	0.00	100	100	0	0	100	N/A	0.00
	0	0	1	1	100	Event	1.00	0	0	1	1	100	Event	1.00
	0	0	1	1	100	Event	4.00	0	0	1	1	100	Event	4.00

Branches » Baseline » Medical Conditions » ICL89_Skin Laceration » Treatment Clusters

ICL89_Skin Laceration

Close

TREATMENT CLUSTERS

Name	Best Case							Worst Case						
	Contribution	Necessity	Equivalence	Rank	Efficacy	Frequency	Quantity	Contribution	Necessity	Equivalence	Rank	Efficacy	Frequency	Quantity
✓ CP1 - History - Collect History of Present Illness Absolute	100	0	0	0	100	N/A		100	0	0	0	100	N/A	
CP1 - History - Collect History of Present Illness	100	100	0	0	100	Event	1.00	100	100	0	0	100	Event	1.00
✓ CP1 - Interpretation - Physical Exam Absolute	100	0	0	0	100	N/A		100	0	0	0	100	N/A	
CP1 - Interpretation - Physical Exam	100	100	0	0	100	Event	1.00	100	100	0	0	100	Event	1.00
✓ CP1 - Physical Exam - Neurological - Focused Exam Absolute	100	0	0	0	100	N/A		100	0	0	0	100	N/A	
CP1 - Physical Exam - Neurological - Focused Exam	100	100	0	0	100	Event	1.00	100	100	0	0	100	Event	1.00
✓ CP1 - Physical Exam - Primary Assessment (ABCs) Absolute	100	0	0	0	100	N/A		100	0	0	0	100	N/A	
CP1 - Physical Exam - Primary Assessment (ABCs)	100	100	0	0	100	Event	1.00	100	100	0	0	100	Event	1.00
✓ CP1 - Physical Exam - Skin Absolute	100	0	0	0	100	N/A		100	0	0	0	100	N/A	
CP1 - Physical Exam - Skin	100	100	0	0	100	Event	1.00	100	100	0	0	100	Event	1.00
✓ CP1 - Physical Exam - Wound Absolute	100	0	0	0	100	N/A		100	0	0	0	100	N/A	

ERRORS

- Input**

- Keystrokes incorrect
- Coding issues
- Orders of magnitude

Capability Contribution	Capability Necessity	Capability Equivalence	Capability Primacy	Capability Efficacy	Resource Phase
#	#	0	0	#	
1	1	0	0	1	CP1 - Patient Encounter And Equipment Setup Time
1	1	0	0	21	Device - E.H.R. Interface Software - E.H.R. Software Software - Pharmacy Dose Tracker Procedure Database - Software Knowledge Database - Software Decision Support Software
1	1	0	0	1	CP1 - History - Collect History of Present
1	1	0	0	1	CP1 - Physical Exam - Primary Assessment (ABCs)
1	1	0	0	1	Hygiene - Skin Cleanser
1	1	0	0	1	CP1 - Physical Exam - Skin

- Transcription**

- Conversion of data
- Categories with coding issues

Capability Class	Capability Contribution	Capability Necessity	Capability Equivalence	Capability Primacy	Capability Efficacy	Resource Phase	
							Bundle
Alternate Cluster:	#	#	0	0	#		
						Software - Medical Knowledge Database - Software	
						Software - Clinical Decision Support Software	
Life Saving	Clinical	1	1	0	0	1	CP2 - Acc Decision
Clinical	1	1	0	0	1	Hygiene - PPE - Non Sterile Gloves	
						Bundle - Irrigation - Irrigation Solution	
Clinical	1	1	0	0	1	Bundle - Irrigation - Irrigation Syringes	

- **Structural**

- “Absolute” versus “Alternate”
- Mixed coding
- “Break” the software

Pharmaceutical - Subcutaneous - Lidocaine - 2% injection Without Epinephrine - 5ml	Pharmaceutical	0	0	1	2	1	4	Event
Pharmaceutical - Subcutaneous - Lidocaine 1% WITH Epinephrine 5ml	Pharmaceutical	0	0	1	3		4	Event
Pharmaceutical - Subcutaneous - Lidocaine 2% WITH Epinephrine 5ml	Pharmaceutical	0	0	1	4		4	Event
Pharmaceutical - Subcutaneous - Bupivacaine 0.5% 5ml	Pharmaceutical	0	0	1	5	1	4	Event
Pharmaceutical - Intravenous - Diphenhydramine 25mg	Pharmaceutical	0	0	1	6	1	2	Event
Pharmaceutical - Intravenous - Sterile Water 1000ml	Pharmaceutical	0	0	1	7	1	0.2	Event

- **Frequency**

- Massive quantities
- “Per Event”
- “Per Day”

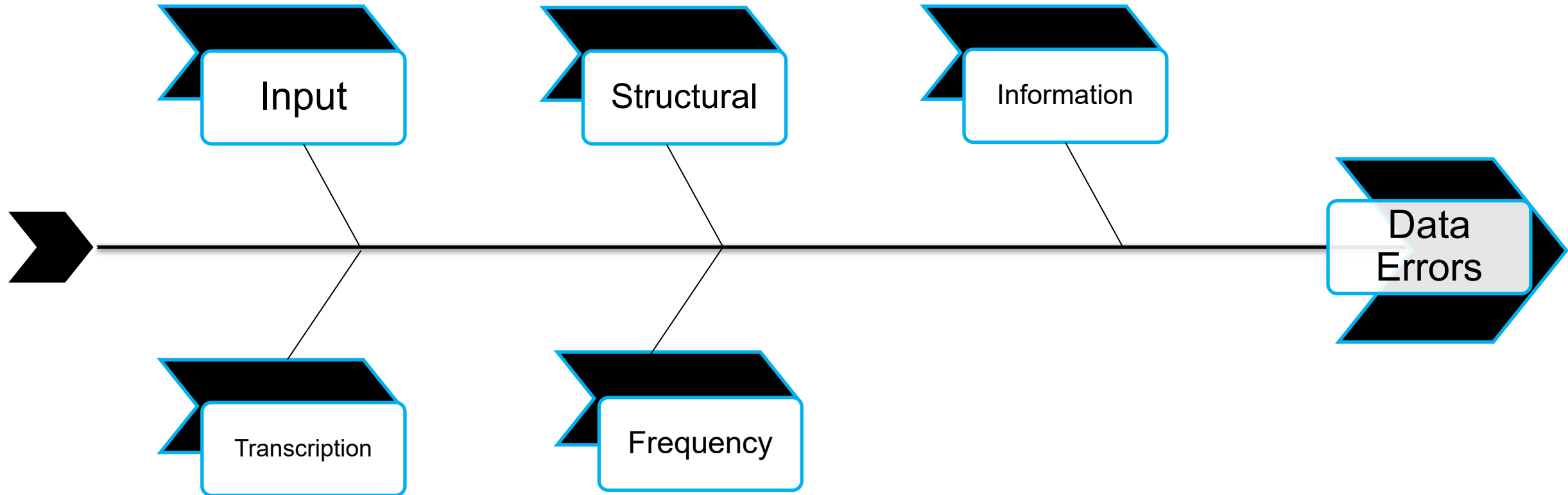
	0	1	3	Event
	0	1	1	Event
	0	1	6	Per Day
	0	1	6	Per Day
	0	1	1	Event
	0	1	7	Event
	0	1	2	Per Day
	0	1	0	NaN

- **Information**

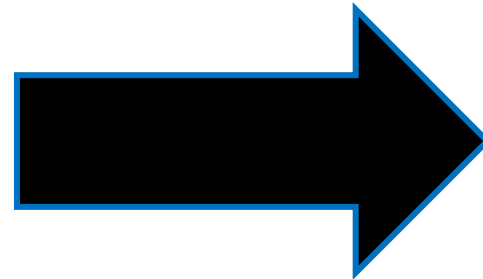
- Dosing
- Inappropriate Capability
- Inappropriate Resource
- Required ExMC Clinical and Science Team (CST) review

Device - Vascular Access - Intravenous Fluid Pump	Clinical	1	1	0	0	1	1	Event
Pharmaceutical - Oral - TMP/SMX 800/160mg	Pharmaceutical	1	1	0	0	1	28	Event
Pharmaceutical - Oral - Levofloxacin 750mg	Pharmaceutical	1	1	0	0	1	14	Event
Pharmaceutical - Oral - Clindamycin 300mg	Pharmaceutical	1	1	0	0	1	112	Event
Pharmaceutical - Oral - Levofloxacin 750mg	Pharmaceutical	1	1	0	0	1	14	Event
Pharmaceutical - Oral - Doxycycline 100mg	Pharmaceutical	1	1	0	0	1	28	Event
Pharmaceutical - Oral - Levofloxacin 750mg	Pharmaceutical	1	1	0	0	1	14	Event
Device - Camera - General Photography	Clinical	1	1	0	0	1	1	Event

Root Cause Analysis



- **Why?**
 - Why?
 - Why?
 - Why?
 - » Why?



- **Systems Errors**
 - Solutions

- **Excel manual data entry**
 - 250,000 cells of data
 - Naming of capabilities, bundles, resources
 - **Software availability**
 - Disseminatable and user familiarity
 - **Time frame and large team**
 - **Large body of work to get operational**
 - **Medical system design lead time**
- **Front end software and training?**

- **Data in Ev Lib doesn't match Excel files**
 - **Data lost or altered in transition to Ev Lib**
 - OR data was incorrect in Excel file
 - **Complex cells with varying information**
 - Large repository of data
 - **Clinical data and coding**
 - Convert clinical decision making and management into algorithms
 - **Software limitations**
- **Software with broader capabilities**

- **“Absolutes” and “Alternates”**
 - **Complex coding scheme**
 - **Accurate modeling and trade space analysis**
 - **Manual entry of coding structures**
-
- **Preset structures**
 - Excel is capable of this but UI may be more intuitive elsewhere

- **Quantity calculations often extremely high**
 - **CRTs inputs separate from incidence and duration data**
 - Scope and goals of the dataset
 - **Broad capabilities but short time frame**
 - **Provide clinically useful data to systems design and operations teams**
-
- **Clear objectives and deliverables**
 - Minimum viable product

- **Built by a CST member**
 - Verified by minimum of 3 other CST members
- **Review meetings**
 - Cell by cell with 99% of cells low variability
 - Discussions and reasoning for clinically significant capabilities
- **Isolated meetings with limited information dispersal**
 - **Documentation of decision making for information entry**
 - **Broader team discussion of high value capabilities**

- Innovation is challenging
 - Create a new approach to clinical decision making
 - Large team effort
 - Many errors where unavoidable
 - Draw on IMM
- Scope is critical
 - Minimum viable product
 - Lay groundwork for future iterations

- Optimized tools optimize work
 - Excel was a necessary evil
 - Future iterations will work with smarter/more precise tools
- Cross team collaboration
 - With the CST and within ExMC
- Difficult but intellectually satisfying
 - Future iterations will continue to improve

Questions?

“Expanding the Boundaries of Space Medicine and Technology”

1. Jones RW, Despotou G. Root Cause Analysis and Health Informatics. *Stud Health Technol Inform.* 2016;226:131-4. PMID: 27350485.
2. Card AJ. The problem with '5 whys'. *BMJ Qual Saf.* 2017 Aug;26(8):671-677. doi: 10.1136/bmjqs-2016-005849. Epub 2016 Sep 2. PMID: 27590189.
3. Su CF, Chu CM, Yuan YJ, Peng CC, Feng CC, Chao SL, Lin CS. Use of a Modified Fishbone Diagram to Analyze Diagnostic Errors in Emergency Physicians. *J Acute Med.* 2017 Dec 1;7(4):149-157. doi: 10.6705/j.jacme.2017.0704.003. PMID: 32995189; PMCID: PMC7517915.