

Research Article

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Using Participatory Simulation to Conduct In situ Ergonomic Simulation in Planning a New Emergency Department

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Planning a new Emergency Department is a serious, long term commitment and undertaking. Adequate time, planning, conceptualization, brainstorming, discussion (Narrative Simulation) as well as testing it all out via in situ simulation (Experiential Simulation, Participatory and Ergonomic Simulation) is critical. Each step of the way, engagement and involvement of stakeholders is important and this would include all levels of staff, medical, nursing and allied health personnel, leadership as well as patients). The involvement of an inter-professional teams cutting various domains requires all to come together to see the completion and achievement of the desired outcomes.

The importance of adequate conceptualization, planning and proper execution cannot be over-emphasized as positive action steps towards a functional, practical, ergonomically planned, state-of-the-art Emergency Department (ED). This paper shares the integration and use of simulation, in its various forms, in the algorithmic approach in planning a new ED.

Keywords: participatory simulation, ergonomic simulation, narrative simulation, experiential simulation emergency department design

Introduction

Medical simulation is a well-recognized technique for both practice and learning, with very broad applications. It is a technique (not a technology) to replace and amplify real experiences with guided ones. It is “immersive” and can evoke or replicate substantial aspects of the real-world experience. Simulation-based learning can be the way to develop health professionals’ knowledge, skills, and attitudes.¹ In situ simulation refers to simulation activities conducted in individual’s or teams’ workplaces or systems.^{2,3} In healthcare this could be in the Emergency Department Resuscitation Room, Intensive Care Unit room, general wards or any other spaces. In situ simulation has well documented advantages and can meet various educational and planning needs.^{4,5} It can help recognize latent threats in the work environment, which may go unnoticed. In situ simulation can test clinical pathways, inter-professional collaborative practice performance, decision making, communications in challenging situations, assessment of new protocols or guidelines and many more. It also serves as a positive resource for Patient Safety and Quality training as well.^{1,3}

Participatory and Ergonomic Simulation

Participatory simulation (PS) is where the future workforce or employees participate in simulation of and at their workplace or their work-related activities. It is usually conducted in situ, also known as ‘work in context’. PS will help to integrate ergonomics and safety aspects into workplace design, pathways and workflow.^{6,7} *Ergonomic simulation* (ES) is where the design, flow or layout of processes and procedures are modelled and tested during simulation activities, to help ensure the products, systems and environment are well integrated, safe, comfortable and efficient. The workers and staff who take part in the ES are thus involved in a PS activity. They are contributing to the decision making and finalization of the workflow and processes they will be utilizing at work.⁶⁻⁸ Following this, the results and observations must be transferred into the final design or the work practice in real life. Ergonomic knowledge transfer will be shared with building specialists, architects and engineers for integration into the workplace design and architectural blueprint or implemented as changes in the steps of a clinical pathway.^{9,10}

When considering ergonomics there are often three categories:^{8, 11-13}

- i. the physical (eg. the environment, infrastructure, injury prevention through design, increasing productivity with

proper design),

- ii. The cognitive (a subcategory of ergonomics that ensure appropriate integration between work, product, environment, human needs, capabilities and limitations) and
- iii. The organizational (i.e. the structures, policies and processes of an organization).

There is strong interlink between all three categories but ii. and iii. are often overlooked when planning. The integration of all three is critical to enhance efficiency and effectiveness.

Use of Participatory Simulation

PS is where stakeholders from single or various domains/ departments come together to refine workflow or clinical pathways, collect inputs and observations, solve problems and make critical decisions.¹¹ Stakeholders play a central and critical role and thus, their active participation is crucial. Their engagement and active inputs must commence as early as possible, even from the conceptualization stages.^{12,13} Their sustained commitment is also very valuable to see the activity or project to completion.^{11,14,15} Their participation can be planned along the lines of the Ladder of Participation, but only certain customizable steps (eg. their appointment/ inclusion into committees or taskforce, active consultation with them, their help with sharing and dissemination of information for inputs and feedback as well as during the execution stages) which are relevant should be used accordingly.¹⁶ Not all steps of the Ladder of Participation are practically implementable, thus case by case consideration is best.^{17,18}

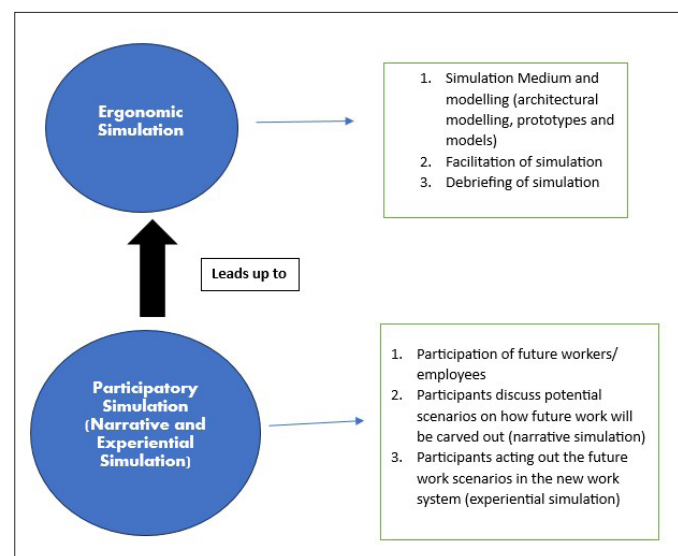


Fig 1: Using Participatory Simulation to conduct Ergonomic Simulation

Some general uses of PS for ES is summarised in **Table 1**. It can be used for partial or full-scale mock-ups and exercises. In order to conduct these there must be both discussants as well as “actors” (can be standardized patients), staff, equipment (comparable or similar models to the ones to be used in the clinical areas) and the appropriate environment (eg. resuscitation room, chest pain unit, observation ward).^{6,7,11,19} This means the personnel involved in the PS can be divided into two categories: (**Fig 1**)

- a. Those who are involved in conceptualization, planning and discussion (known as Narrative Simulation) and
- b. Those who participate in the simulation (known as Experiential Simulation)

Experiential Simulation

Experiential Simulation is the interactive and immersive learning experience that replicates real world scenarios and environment. It provides the authentic situation that can be encountered, but in a controlled setting. Thus, it provides a powerful hands-on learning environment. Experiential simulation helps participants experience realism, the interactivity and adaptability they would encounter in real life situations. Experiential simulation is risk free and can be used to depict diversity and applications, customized to the various work areas.^{1,4,20}

Table 1: Uses of Participatory Simulation for Ergonomic Simulation

- To innovate and test out workplace designs
- To enable evaluation of future ergonomic work conditions
- To fine tune and adjust designs to improve the future ergonomic conditions and safety
- To test out clinical pathway and workflow processes
- To recognize latent threats

The steps undertaken would be:^{1,2}

1. Developing and curating the scenarios (Narrative Simulation)
2. Delivery and execution of the Simulation activity (Experiential Simulation) to test out concepts and workflow
3. Analysis and Debriefing, post simulation and,
4. Evaluation and Follow-up, with appropriate implementation of changes and transfer of ideas/ concepts to the appropriate specialists (eg. building specialists, architects, engineers)

Patient Involvement in Ergonomic/ Participatory Simulation

This is a unique situation where carefully selected patients are involved in the PS. This can help ensure patient needs and expectations are taken into consideration and their perspective of safety can be addressed. These may represent blind spots from the healthcare providers’ perspective. These interventions can help to improve the psychological safety for patients and their relatives using the ED. Such patients can be engaged to be involved in PS testing of patient flow in the ED (i.e. ES), challenging communications encounters in emergent conditions (including breaking bad news and taking urgent informed consent), as well as other situations such as educational messaging, discharge advice, medication prescription etc.^{2,4,18,21}. For institutions that have patient advocacy groups, they can be engaged to assist. At SingHealth, we have The SingHealth Patient Advocacy Network (SPAN) members who participate in some of these exercises.

Emergency Department Design

EDs represent complex systems, which has to function efficiently 24 hours a day. They have a key role in promoting institutions’ goals, especially when they are the “front door” of institutions. In planning EDs, the unpredictability of surge and care requirements must be taken into account. Simulation, in its widest spectrum is valuable as a tool in helping to analyze and optimize complex ED operations and logistical arrangements.^{7,9}

The objectives of designing an effective and efficient Emergency Department (ED) include:^{22,23}

- Proper coordination and streamlined flow of patients and staff from area-to-area
- Adequate and safe environmental control to support work

- execution, as well as for comfort and ease of patients and staff
- Flexibility to negotiate upsurge in capacity, which is of high potential in most established EDs

It is important to understand the importance of functionality in the ED context as well as the form (i.e. the spatial and relationships considerations). Often the patients' needs are taken into account but the staffs' wellbeing and comfort may be overlooked. Planning and designing an ED without considerations for the human factors/ staff will result in dysfunctional outcomes and ergonomic challenges. It is thus very important to get them involved from the early stages. They should be empowered as they have valuable inputs, especially in view that they walk the ED ground daily and they also "feel the footprints" from area to area. Only the ED staff would really understand the nature of work, the changes needed to uplift and improve the situation. They can also explain tasks to the building and construction team, perform demonstrations as needed or even conduct guided tours. They are the best persons who understand these tasks, why they need to be done, movement of staff, use and storage of equipment and consumables as well as many more activities.^{24,25}

Common Pitfalls in ED Design Planning

Some of the common pitfalls in the ED planning and design process stages include:

- Lack of mechanism to engage clinical staff for their inputs. This is crucial as they are the ones running the "shop floor" every day. They are the ones aware of the issues and challenges they encounter ever so frequently. They have the potential to contribute extremely key design decisions, based on their experience.
- Lack of protected time for staff on the taskforce to sufficiently dedicate their focus on the role. This is a very common problem in view of the time constraints as well as challenges in manpower, which happens in most EDs.
- Lack of knowledge on the built environment. This is also often linked to inadequate knowledge on evidence-based design. Thus, in appointing the taskforce, a diversity of staff with various strengths must be incorporated.
- Lack of opportunities to visit the site at the different phases of the work. These staggered visitations for feedback and trial is important, especially whilst changes can still be made. Often the visits come quite late when it is impossible to negotiate further infrastructural or major changes.

Understanding the above is important so that planning and simulation can be incorporated early. The staff themselves are the best to engage in PS as we want to have their inputs on the "touch and feel" of work execution, trial of the flow and movements of patients and staff, as well as testing some of the specialized areas an ED need to incorporate, such as the paediatric and geriatric care areas. Also, the built environment of the ED is complex and special considerations must be given from the early stages. Some of these considerations will include:^{16,19,26-29}

- Way finding and signages
- Lighting
- Finishes
- Sound attenuation
- Privacy and modesty considerations
- Managing the bariatric, geriatric, paediatric patient
- Decontamination areas, effluent management
- Storage of equipment and devices

- Isolation/ negative pressure areas
- Others

Planning the New Emergency Department

i. The Participatory Simulation: Narrative Simulation (Fig 1/ Table 2)

Table 2: Participatory Simulation (Narrative Simulation): Discussions, Brain Storming and Table Top Exercises

Stages	Action	People/ Staff Involved
Conceptualization of Design and Layout (Task Analysis Methodology: collect and analyze data from current ED)	• Literature review, Understand "state of the art" currently • Listing of current facilities design and needed changes/ modifications (may involve current and new site visit • Focused group discussions	• ED Key personnel (HOD, Medical, Nursing, Administration) • Facilities management • Subject matter experts • Engineers • Construction specialists • Ministry of Health Representative
Further Brainstorming Short-listing Confirmation	• Follow up on earlier discussions • Preliminary Confirmation • Artist Impression and modelling	• ED Key personnel (HOD, Medical, Nursing, Administration) • Facilities management • Subject matter experts • Engineers • Architects • Construction specialists • Ministry of Health Representative
Table Top Exercises/Initial Modelling	• Testing out the proposed designs • Initial Confirmation	Same personnel as above
Sharing with wider EM Community and Feedback	• Sharing design and proposal with the ED staff/ personnel • Discussion and feedback (should be open/ subjected to modifications and change as needed) • Reviewing floor plans, footprints for staff from area to area, service offerings and facility	• ED Key personnel (HOD, Medical, Nursing, Administration) • ED staff/ personnel/ employees • Patient representatives (Patient advocacy representatives)
Blue-printing, Anthropometric benchmarking Construction Phase	• Finalization and confirmation before handing over to Construction personnel • Construction of Building/ Department	• Key ED personnel/ Core team • Construction Team • Construction and Building Specialists and team
Strategic Review and Site Visits	• Ongoing, open discussions at regular intervals • Site visits for "look and see"	• Key ED personnel • Construction Team
Adopting changes in Design execution/ Fine-tuning (Multiple steps/ at intervals)	• Final stages • Agreement	• Key ED personnel • Construction Team

Key: ED: Emergency Department

HOD: Head of Department

This commences very early; from the time it is known that a

new ED is upcoming, adequate literature review, visits to other state-of-the-art EDs and brainstorming is necessary. During the Conceptualization of Design stage, deep discussions and all the challenges and problems which staff usually encounter can be surfaced, with a view to rectification and improvement. Focused group discussions are also useful. The group involved in the Narrative Simulation, can also choose to conduct table top exercises, which could be a paper and board exercise or one utilizing figurines and model structures (one example is Lego blocks). This will then lead to short-listing of the proposed designs, which must then be shared with the wider ED community for their feedback and consensus.^{1,3,6,20} Finally, blue-printing and anthropometric bench-making is conducted. The group of key healthcare staff must work with personnel and experts from other domains and industries eg. engineers, architects, building specialists, construction personnel, radiation experts and Ministry of Health administrative officials (or the equivalent, in different countries).^{28,29} This will represent a truly inter-professional team. When healthcare staff work with these other industry personnel and experts, they need to patiently show and share the relevant details and data from the ED perspective. Doing site visits is crucial as well as it gives the idea of the workflow and footprints in the ED. Following the confirmation, the construction phase begins and the key team will still have to, at regular intervals, be consulted and perform site visits. Rectifications are still possible but hopefully, not major ones as these should have been addressed before the construction stages commence.^{19,20,29-31}

ii. Participatory Simulation: Experiential Simulation (Fig 1/ Table 3)

Stage	Action	People/ Staff Involved
Floor/ Cubicle set up and use Arrangement/ ergonomic layout of equipment within each cubicle and on the whole floor/ area	• In situ Simulation	• ED Staff/ Simulation Specialists/ Debriefers
Workflow and clinical pathways (internal and with external partners) Inter-professional Collaborative Practice	• In situ Simulation	• ED Staff/ Simulation Specialists/ Debriefers
Sequential Activities	• Sequential in situ simulation (eg. from EMS personnel delivering patient to the ED, ED management and stabilization and onto the Emergency Operating Theatre or Intensive care Unit)	• ED Staff/ Simulation Specialists/ Debriefers • Staff from the relevant departments/ groups, both upstream and down-stream
Latent Threats	• In situ simulation	• ED Staff/ Simulation Specialists/ Debriefers
Rare cases	In situ simulation for diagnoses such as: • Peri-mortem caesarean section • Emergency Neonatal Obstetric Code • ED Thoracotomy • Malignant Hyperthermia	• ED Staff/ Simulation Specialists/ Debriefers • Staff from the relevant departments/ groups, both upstream and down-stream

Key: ED: Emergency Department
EMS: Emergency Medical Services

Moving ahead into the Experiential Simulation stage, a lot more activity will commence and the healthcare clinical staff will become more highly engaged. This is also where the simulation specialists and subject matter experts will be deeply involved. This PS can be ES which involves checking and testing out the physical and infrastructural set up through in situ simulation. Details are important and using Task Analysis Methodology (just as it is used in the Narrative Simulation stages), breakdown into small bite size components to be tested, is very practical.^{5,7,10} It will cover details such as:²⁶

- placement of furniture and equipment and how it matches patient and staff movement from area to area on the ED
- resuscitation room logistics and layout: such as how equipment is organized and placed for easy reach by the resuscitation team in the course of their work
- infection control familiarization: placement and arrangement of items such as personal protective equipment, hand-rub solutions, masks for easy access when needed
- radiation safety considerations

Table 3 lists examples of some of the types of in situ ES which are commonly conducted in the ED, especially with a new ED facility.

Real World Examples

Applications	Use of PS and ES
Planning the new resuscitation room	- Layout of the resuscitation room, arrangement of furniture and equipment around the cubicle/ trolley for easy reach and accessibility by the team - Planning of overhead X-Rays and lead shielding within the room - Testing for radiation leak - Testing workflow with the inter-professional teams, centred in the ED resuscitation room eg. Trauma team, Stroke team
Testing out Workflow using Sequential Simulation	This involves inter-professional teams and also various locations: - Delivery of the (major trauma) patient from EMS to the ED - Management and stabilization of the patient in the ED - Preparation of the patient to be transferred to the Emergency Operating Theatre for surgery Each step of the workflow process is tested out via in situ sequential simulation
Transfer of Suspected Infectious patient from the ED to the isolation ward eg. patient with suspected and at high risk of Ebola infection	This involves testing the workflow: - Managing the infectious patient with the appropriate PPE just outside the ED (specially prepared area for highly infectious cases) - After stabilization and management, transfer to Isolation ward - The route to take, the elevators to use and the necessary infection control measures are tested via PS/ ES to ensure no collateral spread and proper transfer

Key: ED: Emergency Department; EMS: Emergency Medical

Services; PPE: Personal Protective Equipment

Limitations and Challenges of Participatory and Ergonomic Simulation

Although the use of both PS and ES is very useful in the planning and designing stages as well as the early testing of the ED infrastructure, there are limitations which need to be considered:

1. PS is supposed to be for the 'future workforce' to be involved in and participate. However, often, we need to use the current workforce as the future employees are not recruited or are not in the ED yet. This means we would have to conduct future insitu simulations for them and re-orientate them when they come in. All these will be labour intensive and time consuming
2. The turnover of staff will also have to be considered, which means retraining and refamiliarization will be needed every time there are new batches coming new
3. When simulating "work related activities" it can be very detailed such that every step of the workflow processes are played out. However, due to the dynamicity of the ED situation, these may change quite rapidly. This means it can be very labile and thus, flexibility in design of pathways will be required. Here, we need to manage the mindsets of the staff. Some will need to be the champions of change or 'change agents' in the ED
4. The cognitive ergonomic component parts may be challenging to actually simulate, early on. It can only be practically done when most things are in place and equipment and pathways are confirmed. Thus, leaving this to the later stages is something leaders will have to accept, especially in view that changes and modifications will then be coming on much later. This also emphasizes the need to be very adaptable and flexible in workflow arrangements. More tweaking may be required even towards the end or after moving to the new facilities.
5. Often, the staff taking part in the Narrative Simulation (NS) and the Experiential Simulation (ES) are different groups of people. This means the two groups may not be aligned with what each other is suggesting or referring to. If they can come together for both the NS and ES or the same group of staff can be used for both, it would be better. Otherwise sharing will have to be conducted to aligned both the groups and ensure the reasoning behind the suggestions are clear and agreeable.
6. One of the major challenges with any change is managing the mindsets and expectations of the staff. One way around this is to get the information shared early, create awareness, get them involved and be empowered in the various groups and taskforce. Often overlooked is the psychological safety of the staff; if they feel inclusive and safe, they will likely contribute more ideas and not be afraid to challenge the status quo, which can certainly help move things forward, progressively.

Discussion

Today, simulation has multiple applications and spin-off across a variety of domains. It is not just used in enactment of clinical scenarios for learning but, in so many other ways and aspects, including planning and designing a new ED, which utilizes empirical modelling, testing physical set-ups, planning vertical and horizontal integration of workflow and tasks, decision making as well as inter-professional communications. Planning a new ED is a long-term commitment and must be done right from the conceptualization phase. Simulation in its various forms allows

proper conceptualization, designing and testing out of workflow, even before the actual work performance in the new facility. It enables back-casting and forecasting to be done, adequate visualization of the future state, ensure data fidelity and proper use of data through stakeholders' engagement and participation.³¹

Conclusion

Ergonomics and simulation complements and value adds to healthcare infrastructure planning. The use of research-based and user/ staff centric inputs in the design is critical. Simulation, in its various forms has positive contributions towards planning and designing a new ED.

References

1. Lateef F. Simulation-based Learning: Just Like the Real Thing. *Journal of Emergencies, Trauma and Shock*. 2010;3(4):348-352. DOI:10.4103/0974-2700.70743
2. Medwid K, Smith S, Gang M. Use of insitu simulation to investigate latent threats prior to opening a new emergency department. *Safety Science*. 2015;77:19-24. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0925753515000697?via%3Dihub>
3. Lateef F, Too XY. The 2019 WACEM Expert Document on Hybrid Simulation for transforming healthcare simulation: The mixing and matching. *Journal of Emergencies, Trauma and Shock*. 2019;12:243-247. DOI:10.4103/JETS.JETS_112_19
4. Lateef F. Maximizing learning and creativity: understanding psychological safety in simulation-based learning. *Journal of Emergencies, Trauma and Shock*. 2020;13:5-14. DOI: 10.4103/JETS.JETS_96_19
5. Patterson MD, Geis GL, Falcone RA et al. In situ simulation: detection of safety threats and teamwork training in a high-risk emergency department. *BMJ Qual Saf*. 2013;22(6):468-477. DOI: 10.1136/bmjqs-2012-000942
6. Andersen SN, Broberg O. Transfer of ergonomic knowledge from participatory event into hospital design project. *Work: A Journal of Prevention, Assessment and Rehabilitation*. 2021;68(2):365-378. DOI: 10.3233/WOR-203379
7. Seim R, Broberg O. participatory workplace design: a new approach for ergonomist. *Int J of Industrial Ergonomics*. 2010;40:25-33. DOI:10.1016/j.ergon.2009.08.013
8. Bittercourt JM, Duarte F, Beguin P. From the past to the future: integrating work experiences into the design process. *Work*. 2017;57:379-387. DOI: 10.3233/WOR-172567
9. Gignon M, Amsallem C, Ammirati C. Moving a hospital: simulation- a way to coproduce safer healthcare facilities. *Int J Occup Saf Ergon*. 2017;23(4):589-591. DOI: 10.1080/10803548.2016.1270543
10. Kaba A, Barnes S. Commissioning simulation to test new healthcare facilities: a proactive and innovative approach to healthcare system safety. *Adv in Simul*. 2019;4:17. Available at: <https://doi.org/10.1186/s41077-019-0107-8>
11. Moore KR, Elliot TJ. From participatory design to a functioning infrastructure: a case of urban planning and participation. *J Bus Tech Commun*. 2016;30:59-84. Available at: <https://journals.sagepub.com/doi/10.1177/1050651915602294>
12. Singh A, Baalsrud HJ, Wiktorsson M. Simulation-based participatory modelling in urban and production logistics. A review on advances and trends. *Sustainability*. 2021;14(17). Available at: <https://doi.org/10.3390/su14010017>
13. Muller MJ, Kuhn S. Participatory design. *Commun ACM*. 1993;36(6):24-28. Available at: <https://dl.acm.org/doi/10.1145/153571.255960>
14. Fadier E, De La Garza C. Safety design: Towards a new

- philosophy. *Safety Science*. 2006;44:55-73. DOI:10.1016/j.ssci.2005.09.008
15. Nickson CP, Petrosioniak A, Barwick S et al. Translational simulation: from description to action. *Advances in Sim*. 2021;6:6. Available at <https://doi.org/10.1186/s41077-021-00160-6>
 16. Hurlbert M, Gupta J. The split ladder of participation: A literature review and the path forward. *Environmental Sci and Policy*. 2024;157:103773. Available at: <https://www.sciencedirect.com/science/article/pii/S1462901124001072>
 17. Arnstein SR. A ladder of citizens participation. *Journal of the American Planning Association*. 1969;35(4):216-224. Available at: <https://www.scrip.org/reference/referencespapers?referenceid=2175595>
 18. Schoenfeld EM, Kanzaria HK, Quigley DD et al. Patient preferences regarding shared decision making in the ED: finding from a multi-site survey. *Acad Emerg Med*. 2018;25(10):1118-1128. DOI: 10.1111/acem.13499
 19. Hamza N, Majid M, Hujainah F. SIM-PFED: A simulation-based decision-making model of patient flow for improving patient throughput time in the ED. *IEEE Access*. 2021;9:103419-103439. Available at: <https://dx.doi.org/10.1109/ACCESS.2021.3098625>
 20. Lateef F. IPE, IPP and Team Science: learning together, working together. *Edu in Med Journal*. 2018;10:81-91. DOI:10.21315/eimj2018.10.4.8
 21. Lateef F. The Standardised patient in Asia: Are there unique considerations?. *J Biomed Res Environ Sci*. 2020; 6: 31-35. Available at: <https://www.sciresliterature.org/EmergencyMedicine/AJECCM-ID18.pdf>
 22. Pollack AH, Miller A, Muslim SR et al. PD-aticians: Leveraging physicians and participatory design to develop novel clinical information tools. *AMIA Annu Symp Proc*. 2016;2016:1030-1039. Available at: <https://pubmed.ncbi.nlm.nih.gov/28269900/>
 23. Chetcuti S, Bhowmick K. Simulation on the job: an ICU's report on how insitu simulation has impacted on human factors and ergonomics in the workplace. *BMJ Stel*. 2020;6:39-40. DOI: 10.1136/bmjstel-2018-000348
 24. Brown T. "Design thinking". *Havard Business Review*. 2008;86(6):84-92. Available at: https://www.researchgate.net/publication/5248069_Design_Thinking
 25. Stanton G. The development of ergonomics data for health building design guidance. *Ergonomics*. 1983;26(8):375-393. DOI: 10.1080/00140138308963400
 26. Durning SJ, Arino AR. Situativity theory: a perspective on how participants and the environment can interact. AMEE Guide No. 52. *Med Teach*. 2011;33:188-199. DOI: 10.3109/0142159X.2011.550965
 27. Carayon P, Wood KE. Patient safety: the role of human teachers and systems engineering. *Stud Health Technol Inform*. 2010;153:23-46. Available at: <https://pubmed.ncbi.nlm.nih.gov/20543237/>
 28. Bowen S, McSevery K, Lockley E et al. "How was it for you?". Experience of participatory design in the UK health service. *CoDesign*. 2013;9(4):230-246.
 29. Brodersen C, Dindler C, Iversen OS. Staging imaginable places for participatory prototyping. *CoDesign*. 2008;4(1):19-30. DOI:10.1080/15710880701875043
 30. Ross R, Seckman C. The challenges of moving from construction to operations: overcoming performance issues with staff orientation and training. *Health Facil Manag*. 2016;29(8):37-40.
 31. Geis GL, Pio B, Pendergrass TL et al. Simulation to assess the safety of new healthcare teams and new facilities. *Simul Healthc*. 2011;6(3):125. DOI: 10.1097/SIH.0b013e31820dff30

