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## A Cost-Effective Simulation Model for demonstration of Parenteral drug administration for undergraduate medical students

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### ABSTRACT

**INTRODUCTION:** The curriculum for medical graduates proposed by the MCI, has undergone significant changes. The new curriculum identifies essential skills, describes methods and contexts of teaching, and recognizes standardized measurement of competencies<sup>1</sup>. It focuses on learning critical competencies needed for success in clinical practice and provides standards and a framework for measuring performance<sup>2</sup>. It allows for self, objective, and multisource assessments with mandates to improve the quality of health care and enhance patient safety<sup>3,4</sup>

**OBJECTIVE:** To develop a cost-effective upper limb mannequin for training students in the skill of parental injection techniques to be assessed using objective structured practical examination (OSPE).

**MATERIALS AND METHODS:** Cost effective upper limb was prepared for parenteral drug administration. Each student was able to practice individually. A study questionnaire was given covering aspects of Perception and feedback of the students regarding the mannequins.

**RESULTS:** A Huge percentage (96.87%) of students concurred that simulation is a useful learning method. A large percentage of students agreed that it made the topic interesting and provided a semi-realistic experience. Feedback obtained showed that over half of the students agreed that the mannequins were good.

**CONCLUSION:** The simulation technique provided self-learning of a variety of skills with confidence in a safe and controlled environment without fear of harming patients. Students were able to enhance clinical competence by repeatedly doing the procedure & correcting their mistakes.

**Keywords:** Cost-effective mannequins, injection technique, parenteral drug administration technique, simulation technique, parenteral drug administration skill development

**Introduction:** Almost 2400 years ago, Aristotle wrote: “for the things we have to learn before we can do them, we learn by doing them.” Later American philosopher John Dewey believed that human beings learn through a 'hands-on' approach. It is the idea that we learn more when we actually “do” the activity. By engaging students in hands-on experiences and reflection, they can connect what is learned to what is felt with better understanding. It makes the theories and knowledge learned in the classroom more relevant and meaningful. It allows the student an opportunity to extend his/her efforts, refine their techniques, and develop their skills. It equips them to deal with real-world situations with confidence.

‘Tell me and I forget. Teach me and I remember. Involve me and I learn’ –Benjamin Franklin. As the saying goes this method has numerous advantages, including creating a more engaging training environment and thereby creating stronger connections and memories related to the material taught.

The Medical Council of India (MCI) has proposed that competency-based Medical Education to be implemented in all medical colleges to provide an effective outcome-based strategy & to focus on the orientation and the skills necessary for life-long learning to enable proper care of the patient. Skill acquisition is an indispensable component of the learning process in medicine. NMC has made it mandatory that all 2<sup>nd</sup>-year undergraduates should have skill training & the curriculum reinforces this aspect by necessitating certification of certain essential skills. Use of skills labs, simulated and guided environments are encouraged. The highest level of skill acquisition is a show how (SH) in a simulated or guided environment; few skills require independent performance and certification <sup>5</sup>.

One of the reasons for the changes is the concern for patient safety, which involves various cases of medical injury and medical malpractices that occurred around the world. Simulation training gives chance to practice complex and sensitive processes in a safe, virtual environment.

Simulation training allows students the confidence to handle similar situations in real-life. The practice provided by simulation training builds up confidence and hence satisfaction, as students would feel more competent to handle real-life situations in the future<sup>6</sup>.

### **Materials and methods**

The study was conducted in the Department of Pharmacology, after obtaining permission from the Institutional Ethics Committee. Participants were second-year medical students (2019 batch).

The existing mannequins for demonstrating and teaching techniques for drug administration are expensive. Moreover, are not feasible for long-term use as they are liable to get damaged as a result of multiple punctures by undergraduate students.

We prepared upper limb models for purpose of demonstrating parenteral administration of drugs and providing a simulating environment for the students for learning the techniques of injection.

### **Materials used**

PVC pipes approximating the length of an adult forearm and arm were procured and served as the bony framework

Polyurethane foam sheets, generally used for cushions and sofas were acquired and used as padding material for simulating muscle.

Tubes from Intravenous (i.v) infusion set were used to simulate vessels (veins).

Thin foam sheets commonly used for art and craft purposes were used for simulating skin.

All the mentioned materials were assembled and the upper limb model was prepared (Figure 1). The assembly was done in three layers around the basic framework.

Layer 1 -- PU (Polyurethane) foam sheet was wrapped around PVC pipe framework and served as padding. It also simulated muscle for purpose of intramuscular injection.

Layer 2-- Upon the muscle padding i.v set tubes were arranged imitating the veins for simulating intravenous injection. The ends of the tubes were left unsealed such that the injected solution can flow out of the tube facilitating the confirmation of injection of the solution into the veins (tubes).

Layer 3--The final layer mimicking skin was a thin foam sheet carefully wrapped around the structure. The foam sheet is thin and supple enough such that the hypodermic needle can pierce through easily for intramuscular and intravenous injection. Further, the foam sheet is soft enough to assist the student in palpating the veins (tubes) comfortably. And it could even facilitate training for subcutaneous injection.

Two types of upper limb models were prepared. One model mimicking the forearm was prepared consisting of the i.v set tubing for simulating intravenous injection(Figure 2). An appearance similar to forearm was created by affixing a hand prepared using Plaster of Paris. The second model was that of an arm. It served for the training of intramuscular (i.m) injections. Both the models were suitable for subcutaneous (s.c) injection technique.

A practical session was conducted wherein every student was able to practice the requisite skills on the assembled upper limb models (Figure 3 &4).

### **Study Questionnaire**

After the session, a study was conducted to understand the perceptions of the medical students regarding the session using the mannequins/ simulation, the mannequins used, factors facilitating the learning experience, factors hindering the learning experience and feedback on the session as a whole was taken.

A pre-validated questionnaire covering all the above-mentioned domains was shared with the students.

The responses were collected using a 5-point Likert scale ranging from Strongly disagree to Strongly agree. An open-ended question on the factors hindering the learning experience was asked.

A total of 129 students participated in the session and answered the questionnaire.

### **Data analysis**

The data collected using the questionnaire was entered into Microsoft Excel data sheet and analysed and represented as percentages and proportions.

### **Results**

Out of the 129 students who attended the session maximum (57.35%) were female (Table 1). The age distribution of the participants was in between the age group of 18 to 25. The maximum number of participants were in the age of 19 years – 58.12% (Table-2).

When asked about Practical session on the whole, most of the students (43%) were moderately satisfied and only 2% were not at all satisfied (Chart 1)

Half of the students, in their feedback agreed that the mannequins were good (Chart 2).

The session on the demonstration of techniques of routes of administration as per the CBME curriculum was an enriching experience for the students with ample scope for corrective attempts in learning the requisite skills. The students were very enthusiastic about performing on the assembled mannequins as they had an opportunity for hands-on experience in performing techniques (Table-3,4,5).

## Discussion

Skill acquisition is an intrinsic part of medical education for the development of the student's knowledge, skill, and attitude. Earlier the various routes of drug administration were taught using Lectures as a mode of teaching. The student would later practice and refine these skills on an actual patient. This carried an inherent risk of harm to the subject. It also discouraged multiple attempts required to polish these skills. Hence the NMC now requires a Skill station as a suggested teaching learning medium. Simulation is an integral component of a skill station. Numerous studies have demonstrated the advantages of Simulation-based training <sup>7,8,14</sup>.

Williams et al<sup>9</sup> demonstrated that the simulation experience was rated as a valuable learning experience ( $P < 0.001$ ) and highlighted that this is linked with better academic performance. Simulations allowed the students to link various facets of theory and promotes the improvement of clinical reasoning.

Simulation is a tool for learning and training as well as for assessment of performance. The skills requirement which can be enhanced with the use of simulation includes Technical and functional expertise training, Problem-solving and decision-making skills, Interpersonal and communications skills, or team-based competencies <sup>10,11</sup>.

An ideal simulation tool/equipment should have the following features: the ability to provide feedback, repetitive practice, curriculum integration, and the ability to range the difficulty levels <sup>12,13</sup>.

The educational benefits of simulation in medical education include the following: Deliberate practice with feedback, Exposure to uncommon events, Reproducibility, Opportunity for assessment of learners, and Absence of risks to patients <sup>14</sup>.

We prepared cost-effective mannequins which are easy to construct in comparison to the existing mannequins which are expensive to purchase and maintain in an attempt to facilitate the students in achieving the requisite skills as per the current curriculum. The mannequins were created with an objective to provide a hands-on experience to the students on drug administration through intramuscular, intravenous and subcutaneous routes in a simulated environment so that they learn the skill and practice many times till they develop confidence without the fear of harming the patient.

The practical session conducted in Department of Pharmacology provided a conducive environment for effective learning and was an enriching experience for the students with ample scope for corrective attempts in learning the requisite skills.

The expensive nature of the existing mannequins precludes their use in many institutions. In such situations, cost-effective models which are easy to assemble with accessible materials serve as an alternative solution for smooth conductance of skills training sessions.

### **Advantages**

- Easy to construct/ assemble
- Cost-effective – materials can be obtained at a reasonable budget
- A single model can be used multiple times and doesn't require careful handling as it can be assembled again as and when needed if damaged.
- Could be used for performing techniques for i.m, i.v, and s.c injections
- Doesn't require skilled supervision. Provides scope for multiple attempts and corrective measures till the student learns the skill.
- Could be used for assessment by an OSPE.

### **Shortcomings**

- Not all the routes of drug administration can be simulated and assessed. (There is further scope for developing models for other routes of drug administration)
- Not suitable for assessment of Communication

### **Conclusion**

Simulation techniques using the cost-effective upper limb models provided an opportunity for self-learning of variety of skills with confidence in a safe and controlled environment without fear of harming patients. Students were able to enhance competence by repeatedly doing the procedure & correcting the mistakes done earlier. The simulation models prepared provided scope for building the confidence of the students in learning the requisite skills as prescribed in the competency-based curriculum. The learning experience helped in achieving the shows how (SH) level of competence due to the hands-on experience as compared to the knows-how (KH) level achieved in the traditional lecture-based teaching of 'Routes of drug administration' in Pharmacology. Inculcating such cost-effective models will provide a platform for learning skills as prescribed in the Competency-based curriculum.

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**Conflict of interest**—There are no conflicts of interest

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**Table 1 shows the gender distribution of the respondents**

| Gender | No. of Participants<br>n = 129 | % of Participants |
|--------|--------------------------------|-------------------|
| Male   | 55                             | 42.62             |
| Female | 74                             | 57.35             |

**Table 2 shows the age distribution of the respondents**

| Age in years | No. of Participants<br>n = 129 | % of Participants |
|--------------|--------------------------------|-------------------|
| 18           | 1                              | 0.77              |
| 19           | 75                             | 58.12             |
| 20           | 30                             | 23.25             |
| 21           | 11                             | 8.52              |
| 22           | 9                              | 6.97              |
| 23           | 1                              | 0.77              |
| 24           | 1                              | 0.77              |
| 25           | 1                              | 0.77              |

**Table 3 represents the Perception of the session using mannequins/ simulation**

| SNo  | Question   | Yes               | No        | Maybe       |             |                |
|------|--|-------------------|-----------|-------------|-------------|----------------|
| 1    | It is a very useful learning method  | 125 (96.87%)      | 4 (3.1%)  |             |             |                |
| 2    | Proper instructions were given before working with an unfamiliar mannequin | 111 (86.02%)      | 7 (5.42%) | 11 (8.52%)  |             |                |
| S.No | Question   | Strongly Disagree | Disagree  | Neutral     | Agree       | Strongly Agree |
| 3    | Provided an opportunity for hands-on experience                            | 5 (3.87%)         | 3 (2.32%) | 15 (11.62%) | 73 (56.57%) | 33 (25.57%)    |
| 4    | Made the topic routes of drug administration more interesting              | 1 (0.77%)         | 3 (2.32%) | 3 (2.32%)   | 70 (54.25%) | 52 (40.3%)     |
| 5    | It is a useful method for learning the skill of performing                 | 4 (3.1%)          | 4 (3.1%)  | 8 (6.2%)    | 66 (51.15%) | 47 (36.42%)    |

|    |   |               |                |                |                |                |
|----|---|---------------|----------------|----------------|----------------|----------------|
|    | Iv, Im, and sc injection  |               |                |                |                |                |
| 6  | Helped in application of knowledge gained in theory classes/ after lecture on the topic                                     | 5<br>(3.87%)  | 2<br>(1.55%)   | 11<br>(8.52%)  | 75<br>(58.12%) | 36<br>(27,9%)  |
| 7  | Helped in retaining the knowledge gained  | 3<br>(2.32%)  | 2<br>(1.55%)   | 10<br>(7.75%)  | 75<br>(58.12%) | 39<br>(30.22%) |
| 8  | Provided a semi-realistic experience  | 4<br>(3.1%)   | 3<br>(2.32%)   | 19<br>(14.72%) | 74<br>(57.35%) | 29<br>(22.47%) |
| 9  | Provided an opportunity for improving my psychomotor ability in using the equipment (syringes) and performing the technique | 4<br>(3.1%)   | 4<br>(3.1%)    | 15<br>(11.62%) | 81<br>(62.77%) | 25<br>(19.37%) |
| 10 | Adequate number of models were available for the session  | 10<br>(7.75%) | 21<br>(16.27%) | 32<br>(24.8%)  | 48<br>(37.2%)  | 18<br>(13.95%) |
| 11 | The duration of the session was adequate for learning process   | 1<br>(0.77%)  | 15<br>(11.62%) | 17<br>(13.17%) | 71<br>(55.02%) | 25<br>(19.37%) |
| 12 | Opportunity was given to perform the procedure till I gained confidence   | 4<br>(3.1%)   | 16<br>(12.4%)  | 38<br>(29.45%) | 43<br>(33.32%) | 28<br>(21.7%)  |
| 13 | More such simulation models be used for learning  | 2<br>(1.55%)  | 4<br>(3.1%)    | 11<br>(8.52%)  | 71<br>(55.02%) | 41<br>(31.77%) |



|        |  |  |  |  |  |  |
|--------|--|--|--|--|--|--|
| skills |  |  |  |  |  |  |
|--------|--|--|--|--|--|--|

**Table 4 represents the Perception of the model/ mannequin**

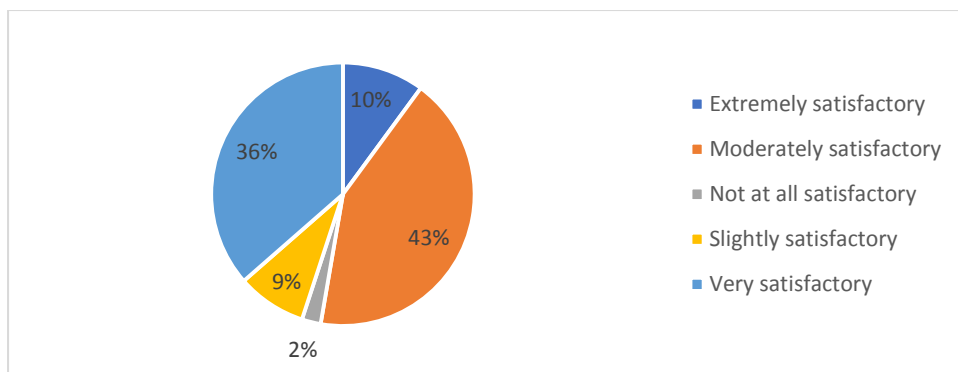
| S. No | Question   | Yes               |               | No             |                |                |
|-------|--|-------------------|---------------|----------------|----------------|----------------|
| 1     | Were similar to arm and forearm/ mimicked arm or forearm               | 108<br>(83.7%)    |               | 21<br>(16.27%) |                |                |
| S. No | Question   | Strongly Disagree | Disagree      | Neutral        | Agree          | Strongly Agree |
| 2     | The models were comfortable being worked on / performing the procedure | 1<br>(0.77%)      | 6<br>(4.65%)  | 24<br>(18.6%)  | 73<br>(56.57%) | 25<br>(19.37%) |
| 3     | I was able to perform the procedure multiple times on it               | 5<br>3.87%        | 10<br>(7.75%) | 38<br>(29.45%) | 56<br>(43.4%)  | 20<br>(15.5%)  |

**Table 5 represents the factors facilitating the learning experience**

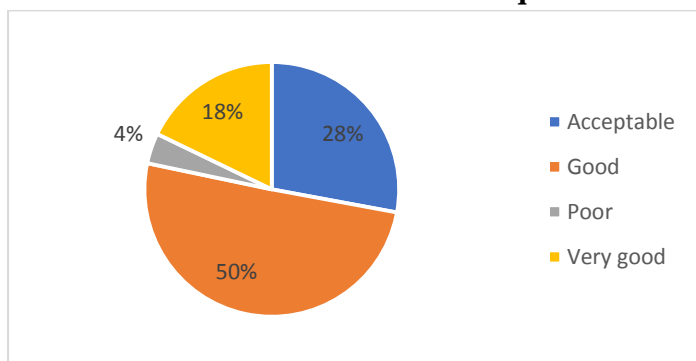
| S. No | Question   | Strongly Disagree | Disagree     | Neutral        | Agree          | Strongly Agree |
|-------|--|-------------------|--------------|----------------|----------------|----------------|
| 1     | I got an opportunity for hands-on experience   | 2<br>(1.55%)      | 12<br>(9.3%) | 27<br>(20.92%) | 67<br>(51.92%) | 21<br>(16.27%) |
| 2     | I was able to learn the procedure well by doing it myself when compared to listening to a lecture on the procedure | 2<br>(1.55%)      | 6<br>(4.65%) | 13<br>(10.07%) | 81<br>(62.77%) | 27<br>(20.92%) |
| 3     | It was my first practical experience working on mannequins /models   | 1<br>(0.77%)      | 6<br>(4.65%) | 12<br>(9.3%)   | 80<br>(62.0%)  | 30<br>(23.25%) |
| 4     | It was the first practical session after online classes  | 1<br>(0.77%)      | 1<br>(0.77%) | 9<br>(6.97%)   | 86<br>(66.65%) | 32<br>(24.8%)  |
| 5     | It was an interesting  | 2                 | 2            | 8              | 85             | 32             |

|   |  |              |               |                |                |                |
|---|--|--------------|---------------|----------------|----------------|----------------|
|   | and fun way of learning  | (1.55%)      | (1.55%)       | (6.2%)         | (65.87%)       | (24.8%)        |
| 6 | I felt like a professional (doctor) injecting the patients                       | 3<br>(2.32%) | 9<br>(6.97%)  | 39<br>(30.22%) | 54<br>(41.85%) | 24<br>(18.6%)  |
| 7 | I got an opportunity to repeat the procedure till I could perform it confidently | 1<br>(0.77%) | 24<br>(18.6%) | 29<br>(22.47%) | 53<br>(41.07%) | 22<br>(17.05%) |
| 8 | I got an opportunity to learn without the fear of harming the patient.           | 3<br>(2.32%) | 11<br>(8.52%) | 23<br>(17.82%) | 61<br>(47.27%) | 31<br>(24.02%) |

**Chart 1 - Practical session on the whole**



**Chart 2 - Feedback about the mannequins**



**Figure 1 : Figure representing preparation of Mannnequins**



**Figure 2 : Figure showing upper limb Mannequins for intravenous injection**



**Figure 3 : Figure representing students performing on Mannequins for I.V injection**



**Figure 4 : Figure representing students performing on Mannequins for I.M injections**

