

BIOE Team 11: A Modified Syringe Design to Simplify the Preparation of Weight-Based Pediatric Medication

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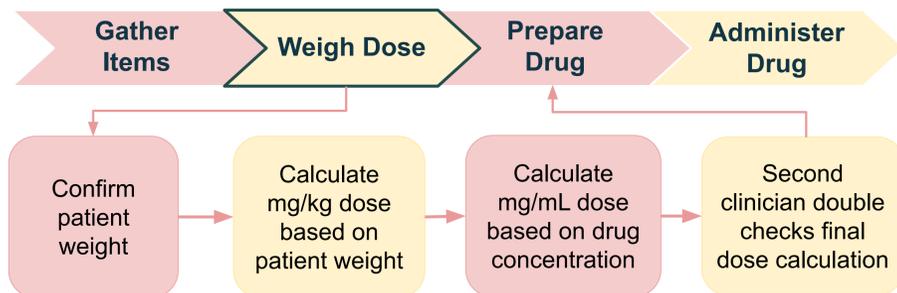
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Objective

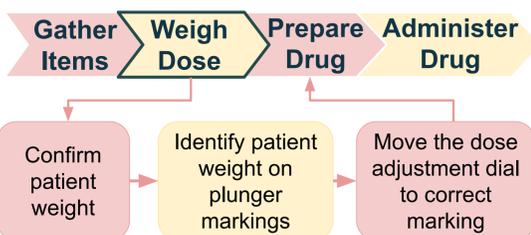
Adverse Drug Effects (ADEs): unintended, harmful effects attributed to medicine use, including dosage errors

- Can result in ineffectiveness of treatment, toxicity, or death
- Dosage errors are **3x** more common in children than adults¹
- Reported incidence of ADEs in hospitals is **6.5 per 100 admissions**²

“Simplify current workflow by eliminating hand calculations, and instead use our modified syringe and dose adjustment dial to determine the correct dose”



Methods



- **Dose Conversion Analysis:**
 - Epinephrine as the main drug focus
 - Calculated dose → 0.01 mg/kg of body weight³
- **Time of Use Assessment:**
 - Time trials to compare preparation time between workflow and syringe
 - Calculate the average time to adjust the syringe and estimate final time

Table 1. Appropriate dosage of 1:10000 Epinephrine in mg and mL given patient weight

| Weight (kg) | mg | mL |
|-------------|------|-----|
| 5 | 0.05 | 0.5 |
| 7 | 0.07 | 0.7 |
| 10 | 0.1 | 1 |
| 12 | 0.12 | 1.2 |
| 15 | 0.15 | 1.5 |
| 18 | 0.18 | 1.8 |
| 20 | 0.2 | 2 |
| 22 | 0.22 | 2.2 |
| 25 | 0.25 | 2.5 |
| 27 | 0.27 | 2.7 |
| 30 | 0.3 | 3 |

Prototyping and Results

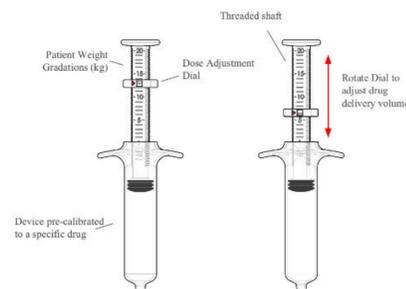


Figure 1. Computer rendered model of preliminary syringe design

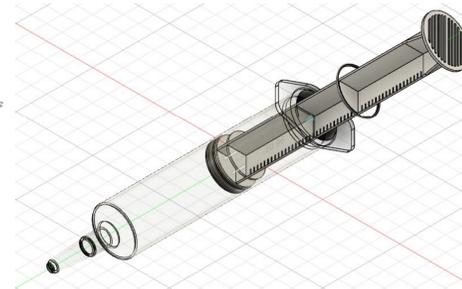


Figure 2. CAD assembly of first prototype of modified syringe

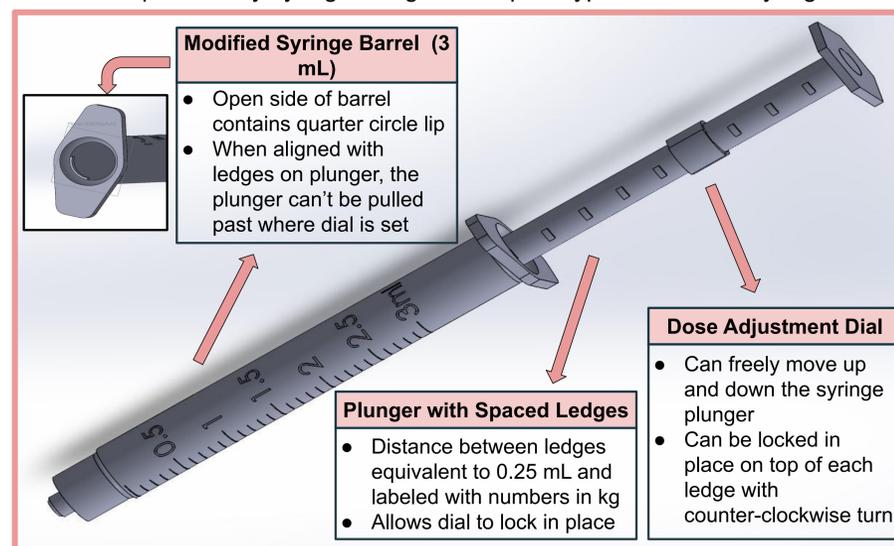


Figure 3. CAD Assembly of modified syringe design

- **Innovative Approach to Syringe Design:**
 - Cylindrical plunger with weight based markings
 - Dose adjustment dial for smooth sliding, rotating, and locking in place
- **Results:**
 - Typical time to dose is ~1 minute⁴
 - Reduced time to draw and administer drug by 40%



Figure 2. Estimated syringe preparation time with modified design vs. current workflow

Bioethical Implications



Patients

- Receive accurate doses tailored to weight, reducing the risk of under and overdosing



Clinicians

- Reduced risk of calculation error
- Improved patient safety



Hospital Administration

- Cost savings
- Reduced liability for the hospital

Conclusions

- **Cost effective device** that addresses the biomedical problem of medical dosage errors
- **Prevents improper medication dose** from being administered to patients
 - Underdosing, overdosing, and adverse reactions
- **Simplifies** the dosing process
 - Setting the appropriate dosage vs. patient's weight
 - Reduces the risk of manual calculation errors
 - Streamlines the medication administration process

Future Work



Usability Testing

- **Clinician Experience**
 - Conduct user testing with clinicians
 - Gather feedback on ease of use, and overall satisfaction with the device



Scaling and Manufacturing

- Evaluate scalability of syringe manufacturing
- Obtain necessary regulatory approvals

References

1) Kaushal R, Bates DW, Landrigan C, et al. Medication errors and adverse drug events in pediatric inpatients. *JAMA*. 2001;285(16):2114-2120. doi:10.1001/jama.285.16.2114
 2) Oyebode F. Clinical errors and medical negligence. *Med Princ Pract*. 2013;22(4):323-333. doi:10.1159/000346296
 3) Dreborg, S., Walter, G., & Kim, H. (2022). International recommendations on epinephrine auto-injector doses often differ from standard weight-based guidance: a review and clinical proposals. *Allergy, asthma, and clinical immunology: official journal of the Canadian Society of Allergy and Clinical Immunology*, 18(1), 102. https://doi.org/10.1186/s13223-022-00736-5
 4) Andersen LW, Berg KM, Saindon BZ, et al. Time to Epinephrine and Survival After Pediatric In-Hospital Cardiac Arrest. *JAMA*. 2015;314(8):802-810. doi:10.1001/jama.2015.9678