5 Wheel Attachment to Current Stair Chair Models for Safe and Efficient Transport of Patients in EMS Settings

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Introduction

Background
- About 28.5 million annual EMS activations[1]
- Patients must be extricated from scenes to receive further care or transport

Problem
- Current technology lacks the capability for safe and efficient transport of patients up staircases.

Needs Statement
- A compact and easily-operable transportation device for use by emergency medical crews to move patients with limited mobility up and down stairs.

Current Solutions

Stairchair

Reeves

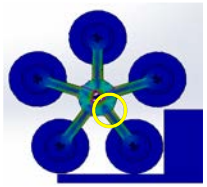
Proposed Solution

Final Attachment Design
- 5-wheel design connected with spokes to center hub
- Each wheel functions separately to allow for normal transportation
- Design allows for rotation of entire attachment
- Bottom wheels rotate when stepping up stairs
- Material Composition: Frame (Aluminum), Wheels (High-Strength Plastic)

Final Device Design
- 5-wheel design is attached to staircase model
- Allows for attachment to be utilized when transporting up stairs
- Maintains treads from original model to permit transport down staircases

Testing

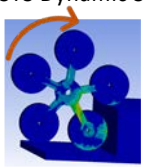
Static Simulation:



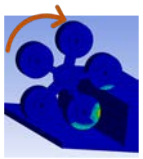
Applied torque about the central axis equivalent to a total weight of 400lbs (chair + patient)

Peak Stress: 19.9 MPa
Factor of Safety: 12

ANSYS Dynamic Simulation:

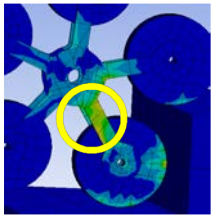


Rolling Stress

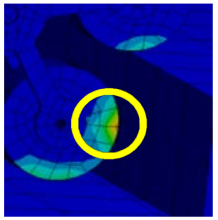


Rolling Strain

Attachment-only rolling simulation (no patient force applied) to identify the location of peak stress and strain within the aluminum frame

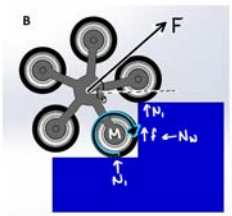


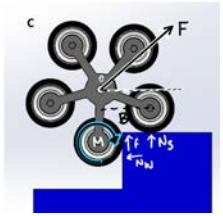
Peak Stress: 0.261 MPa



Peak Strain: 3.51e-4

Provider Effort Analysis:





The required force to pull the modified stair chair up a set of stairs is **57.46%** of the total weight of the patient and chair compared to lifting 100% of the total weight in current stair chairs.

Market Analysis

Manufacturing & Retail Information

Part Description	Qty (/unit)	Small Scale Unit Cost	Large Scale Unit Cost
Aluminum 6061 (Wheel Frames)	4	$ 23.06	$ 17.01
Polyurethane Wheel	10	$ 258.70	$ 5.00
Bronze Sleeve Bearing	4	$ 7.52	$ 7.52
Steel Wheel Axle	10	$ 22.60	$ 22.60
Total Attachment	N/A	**$ 311.88**	**$ 52.13**

Patentability
- Potentially obvious combination of existing products (Mitchell Industry Dolly Innovations tires[4] and Stryker stair chair[5])
- Possible ornamental patent dependent on attachment design

Reimbursement
- Cost of patient extrication included in base cost of ambulance service, so our device incurs zero additional cost to patients
- Minimal cost increase for EMS, as Stair chair devices are replaced about once every 10 years

Conclusions

Our device is:
- Dual-purpose: can transport patient both up and down staircases
- Safe: 5-wheel design decreases the force required for extrication by EMS providers by 43%
- Unique: no other product on the market can manually transport a patient up a flight of stairs

Future Work: the next step is to create and attach the physical 5-wheel design to a stair chair

Acknowledgements

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References

1. The National Registry Data Dashboard. (2017, April 13). In The National Registry. Retrieved 17 November 2019, from www.nremt.org/rwd/public/data/maps
2. "Stryker Model 6252 Stair Pro Stair Chair." Save Lives, Common Cents EMS Supply, www.savelives.com/product/stryker-model-6252-stair-pro-stair-chair-7000.cfm
3. "Stretcher, Reeves Style Flexible." Penn Care, Penn Care, Inc., www.penncare.net/product/stretcher-reeves-style-flexible/
4. "Shop: Stair Walking Hand Trucks." *Mitchell Industrial Dolly Innovations*, dollyinnovations.com/shop/.
5. "Stair-PRO." *Stryker EMS | Stair Chair Products*, Stryker Corporation, ems.stryker.com/en/stair-chair.

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