Patient Transfer Chair

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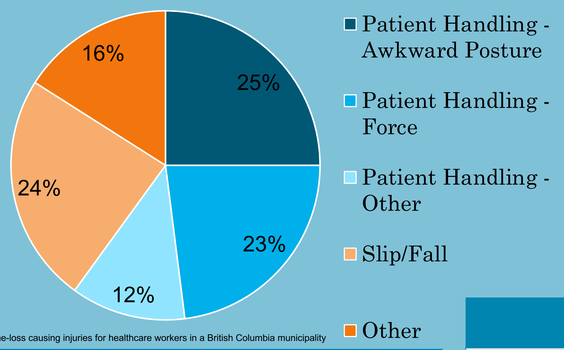
Project Scope

Design an efficient and dignified transfer system for bedridden patients, reducing risk to the patient and operator. The system must transfer the patient from a hospital bed to a mobile chair and vise versa with minimal assistance.

Leading Causes of Injury for Direct Patient Care Occupations*

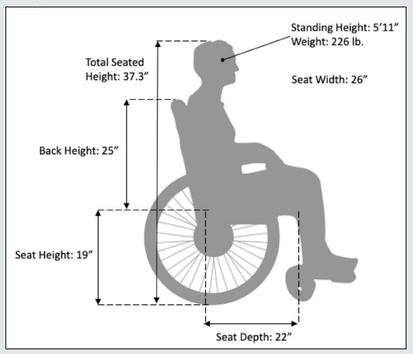


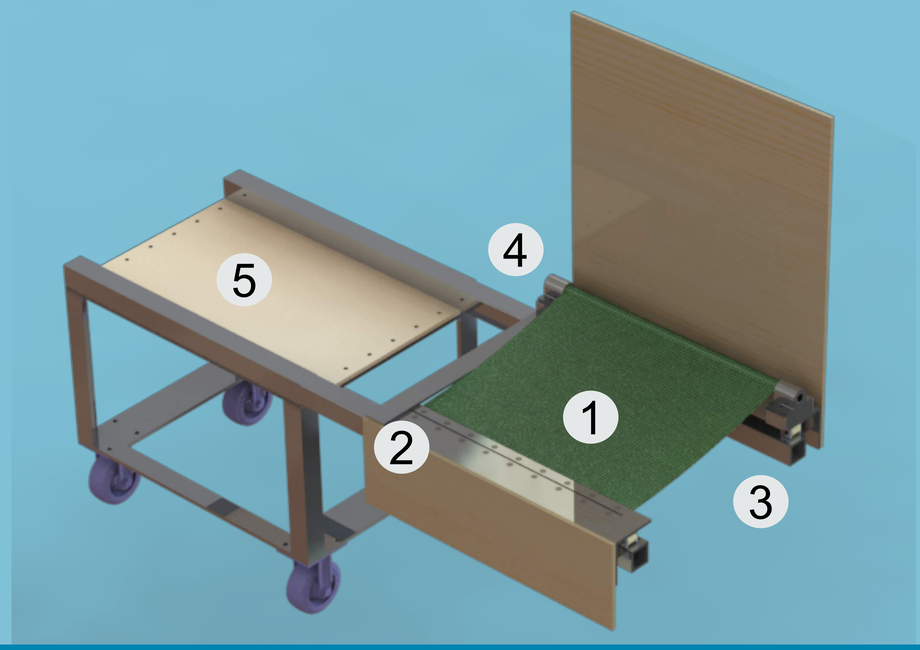
*Of 944 time-loss causing injuries for healthcare workers in a British Columbia municipality

Requirements

1. Shall operate safely, with a safety factor of 5.
2. Shall operate for patients within the target population as specified in the below figure.
3. Shall operate for patients with ergonomic dimensions within the target population as specified in the below figure.
4. Shall be operable by one auxiliary operator
5. Shall be operable with no more than 50 lb pushing force, 24 lb force from the shoulder or arm muscle.

Target Population Upper Design Limit: The Elderly 99th Percentile Man





Chair Operation

Transfer: Chair to Bed

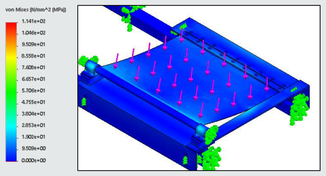
1. Patient sits on the tightened fabric seat (1)
2. Rods (3) are inserted in to chair base (5) and positioned over the bed
3. Seat frame (2) is pushed over the rods (3) until on top of bed
4. Fabric is loosened using the winch (4) until the patient is seated on the bed
5. Fabric slides out from underneath the patient
6. Rods are removed and frame is moved back over chair base (5)

Transfer: Bed to Chair

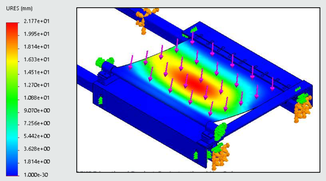
1. Rods (3) are inserted in to chair base (5) and positioned under knees and back of patient knees and back
2. Seat frame (2) & fabric seat (1) slide underneath patient
3. Fabric (1) is tightened and patient is lifted
4. Frame seat (2) is pulled until positions above chair base (5)
5. Rods (3) are removed
6. Chair and patient are now mobile

Simulations and Testing

Finite Element Analysis on Frame Structure



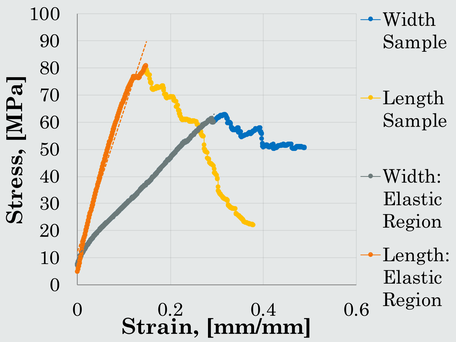
(Body Stress)



(Displacement)

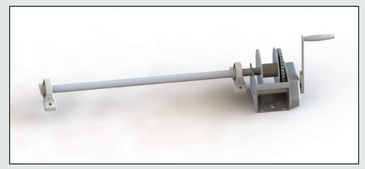
- Static weight of 260 lbs. on fabric seat
- Maximum URES deflection < 22 mm
- Maximum Von Mises stress < 115 MPa in design and < 22.5 MPa in fabric, within safety factor

Seat Fabric Stress Strain Curve



- Modulus of Elasticity was taken from a linear approximation in the above stress-strain curve.
  - Length Sample = 522 MPa
  - Width Sample = 178 MPa
- The fabric has an ultimate tensile strength of 86 MPa which exceeds the calculated 22.5 MPa required.

Force Analysis of Winch and Shaft



With safety factor of 5:

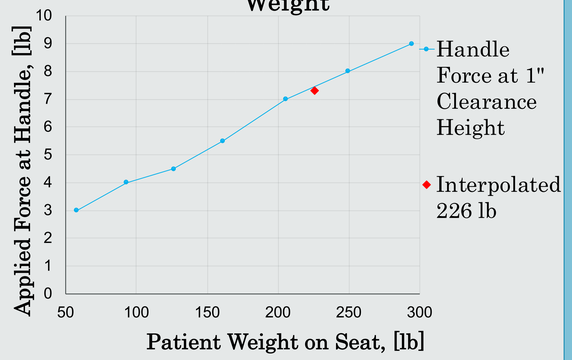
- Max bending stress on shaft = 294.1 MPa
- Max shear force on shaft = 2.3 kN

AISI 1020 Steel:

- Yield Strength = 350 MPa
- No risk of yielding

Verification

Handle Force Required to Lift Patient Weight



- Operator handle applied force at clearance height with patient seat weight of 226 lb was 7.3 lb.
- Patient seat requirement was exceeded to a tested weight of 295 lbs with no deflection in structure.
- Operator applied shoulder force requirement was significantly less than 24 lbs, reaching a maximum of 9 lbs at a patient weight of 295 lbs.

Future Recommendations

- Linear bearings to replace the current seat wheel rolling system. This will reduce the force necessary to move the seat frame. The addition of linear bearings will also reduce bulk in the seat frame.
- Telescoping rods, compatible with the linear bearings, for a more compact design.
- A reversible ratchet on the winch to reduce the risk of a sudden drop when loosening the fabric.
- Addition of hydraulic system to make the chair compatible with beds of different heights.
- Addition of a swivel base to increase accessibility and patentability.
- Revision to materials approved by Health Canada for use in hospitals.

References

- Associates, H. D. (2002). The Measure of Man and Woman - Human Factors in Design. New York: John Wiley & Sons.
- Ngan, S. Drebit, S. Siow, S. Yu, D. Keen, H. Alamgir; Risks and causes of musculoskeletal injuries among health care workers, Occupational Medicine, Volume 60, Issue 5, 1 August 2010, Pages 389–394, https://doi.org/10.1093/occmed/kqq052