Pushing Forces and Risk of Injury to Food Service Workers  
- AN ERGONOMIC ASSESSMENT -

Date: October 20-21, 2000  
Location: Enderby, B.C.  
Facility: Enderby Hospital  
Contact: Sue McInnis, Manager of Rehabilitation Services, Chair MSIPP

Objective:  
To perform an ergonomic assessment of pushing forces and risk of injury to Food Service Workers (FSWs) to determine the appropriateness of a motorized “push-puller” and provide recommendations.

Background:  
An application for $10,000 has been submitted by the Manager of Rehabilitation Services to reduce the risk of injury to food service workers through the modification of their bulk food delivery system. Enderby Hospital is located in two facilities. The two buildings, Enderby Hospital and Parkview Place, are connected by an outside cement driveway and ramp. Food is prepared in Enderby Hospital and then transferred to the second floor of Parkview Place via the driveway and ramp. It has been proposed by management that a motorized “push-puller” might improve current working conditions.

Fig. 1  
The ramp connecting the two buildings
Methods:
1) **Task analysis for pushing cart** – describes physical activities required to move the cart from Enderby Hospital to adjacent Parkview Place (Observations of FSWs).
2) **Task analysis for a shift** – breaks down job requirements into main tasks, subtasks of main tasks, and frequency and duration required to perform tasks (Observations of FSWs).
3) **Force Measurements** – measures of pushing force at various places along the pathway to determine average forces required to push the cart from Enderby Hospital to Parkview Place (Chatillon Force Gauge is placed against the cart handle and used to push the cart from a standstill to FSWs walking speed).
4) **Informal Interviews** – unstructured interviews with FSWs and cooks to collect additional information about their concerns and suggestions regarding the current system.
5) **Physical and environmental constraints** – describes the layout of the facility, including dimensions of the cart, cement driveway and ramp, and how different environmental factors may affect worker ability to push the cart (Observe workers load/unload cart and push the cart from Enderby Hospital to Parkview Place).

Findings:
1) **Task analysis of pushing cart**
   Food is prepared in the kitchen, which is located in the basement of Enderby Hospital, and then transferred to Parkview Place. The cart is used 3 times per day (breakfast, lunch and dinner) for 365 days a year. Most workers push the cart once per shift.

   Two FSWs place prepared food (stored in metal food bins) into three insulated boxes attached to the top of the cart. The insulated boxes are closed and any additional food items (i.e. cans of food, milk cartons, etc.) are placed on the rack located lower to the ground.

   ![Food cart box](image)

   At the front of the cart is an adjustable metal bar that comes out perpendicular to the cart, allowing one FSW at the front to push while standing beside the cart. A second FSW pushes the cart from behind. This design enables the first FSW to push instead of having to pull. The cart is pushed out of the kitchen and into an elevator. The elevator brings the cart to the main floor where the cart is then pushed approximately 12-15 metres through the hallway of the acute care ward and out the back door. The cart is then pushed across 15 metres of paved driveway and up a 25 metre ramp (4.8° incline). The
ramp is “L” – shaped, necessitating a clockwise 90° turn before proceeding to the top of the ramp. A gate is located at the top of the ramp on the left hand side. The cart is turned 90° counterclockwise and pushed through the gate. The FSWs push the cart 8 metres across a level cement pathway, and through a second gate that does not require the cart to be rotated. Parkview Place’s door is located on the right hand side of the pathway. The cart is turned 90° to face the door and is then pushed through the door. The cart is pushed a few more metres into the food service area and the food is unloaded. The cart is then pushed back along the same pathway to Enderby Hospital’s kitchen. On the return route, FSWs hold on to the cart to prevent it from moving too quickly down the ramp.

2) Task Analysis of a shift for Position #5

Task Breakdown:

Note: Percentages have been rounded up to nearest percent and breaks have been excluded from total shift time. Breaks include two 15-minute coffee breaks and one 30-minute lunch break. Total shift time excluding breaks: 7 hours

Task: Cut and clean vegetables/fruit: 16% of shift

Example subtask: Cutting and peeling potatoes

- Frequency: 1 potato peeled/15 seconds, 1 potato cut/3 seconds
- Duration: 15 minutes
- Forces: Pinch grip, intermittent static wrist flexion, etc.

Task: Clean and put away dishes: 36% of shift

Example subtask: Scrub pots

- Frequency: Varies (Observed light scrubbing)
- Duration: 15 minutes
- Forces: Intermittent static back flexion, pinch grips, static wrist extension, shoulder protraction and flexion, etc.

Task: Clean equipment/counters: 17% of shift

Example subtask: Clean and sanitize sinks

- Frequency: N/A
- Duration: Varies (10-20 minutes)
- Forces: Static back flexion, elbow flexion, shoulder protraction and flexion, etc.

Fig. 3

FSW cleaning counter in dish room

Task: Food/tray preparation: 26% of shift

Example subtask: N/A
Task: Push Cart: 6% of shift
- Frequency: once per shift for Position #1, #1a, #3, #6,
  twice per shift for Position #5
- Duration: approximately 10 minutes per trip
- Forces: Dynamic exertion, two-handed push, slight back flexion

Note: After reviewing job duties for kitchen positions, it has been determined that two
positions require no pushing of the cart, four positions require pushing the cart once per
shift, and one position requires pushing the cart twice per shift.

3) Force Measurements:
Force measures required to push the cart were recorded with a Chatillon Force Gauge. Force measures were taken inside Enderby Hospital, on the cement driveway, and on the ramp. Force measures were taken on a fall day with light precipitation. Forces in the snow or ice may be somewhat different. Each measurement consisted of several trials for the initial and sustained forces required to push the cart.

Force measures were compared against Snook Tables (Snook and Ciriello 1991) that detail allowable loads for pushing forces (taking into account handle height, pushing frequency, distance pushed, and the percentage of the female population pushing.)

Pushing the cart up the ramp was found to be the most difficult, with force readings averaging 108N (initial) and 81.4N (sustained). Measures for other parts of the pathway between the two buildings were considerably lower than the forces on the ramp. Taking this into account, overall force readings for initial and sustained pushing were much lower than those calculated on the ramp alone. Average forces on the flat cement driveway were recorded at 40.2N (initial) and 17.7N (sustained). Overall forces that include pushing forces inside the building were calculated to be 33.6N (initial) and 21.6N (sustained).

Comparisons of force measures, the handle height of the cart, frequency of pushing, distance pushed, and a population percentile of 90% female were compared with recommended averages. Results indicate that initial and sustained forces required to push the cart along the pathway and up the ramp are within recommended allowable loads acceptable to 90% of females.

4) Informal Interviews:
Workers commented that, of all tasks, it is most difficult to push the cart up the ramp. The cart requires two people to push because it is too difficult to steer with only one person. Though it was not observed, workers also stated that the cart is more difficult to push when extra supplies are added to the cart.

Environmental conditions also play an important factor. The ramp is heated, causing snow to melt and run down to the bottom of the ramp (not heated) where it then refreezes and forms a sheet of ice. Staff indicated that this creates a potential slipping hazard, and makes it more difficult to maneuver and push the cart. Pushing the cart in the winter
means that transfers are done in poor weather for up to 5 months of the year. Snow, ice, rain and reduced visibility, combined with cold temperatures, make pushing the cart outside more difficult than in the summer months. Staff mentioned that a smaller, lighter food cart might lessen the risk of injury and be easier to use.

5) Physical and environmental constraints:

- Protrusions: screws protrude from the wheels of the cart (a previous WCB claim was due to a worker’s ankle hitting the screw)
- Wheel-type: they may not be the most appropriate style for the surfaces they are used on
- Cart steerage: four swivel wheels contribute to the difficulty of maneuvering the cart
- Cart weight: the existing cart is too big and too heavy with respect to the amount of food transferred
- Cart control: FSWs must be careful when pushing the cart through the hallway in the acute care ward because patients sometimes move directly into the path of the cart
- Cart design: the length of the pole for pushing is too long, making it difficult to maneuver without running into doorways and walls. In addition, staff are at risk because their hands can get caught between the bar and doorways/walls.

Fig. 4
Food cart box with pole extended

- Cart size: the cart width of 63.5 cm (63.5 cm with pole in, 120.7 cm with pole extended), makes it difficult to maneuver through some doorways (worst doorways have only enough clearance to barely allow the cart through)

Fig. 5
Gate at the top of the ramp
• Cart height: the insulated boxes for food storage is 74.9 cm (most of the workers were bending at the waist to add and remove food from the boxes)
• Ramp condition: at the bottom of the ramp the concrete is cracked and uneven
• Ramp obstacles: workers must maneuver the cart through a narrow gate
• Ramp design: when entering Parkview Place the cart must be rotated 90° anticlockwise in a physically constrained area to move it into the unloading area
• Ramp incline: going down the ramp requires workers to hold the cart to prevent it from gaining too much speed. FSWs lean backwards with arms flexed slightly and take small steps to control the speed of the cart.

Discussion:
Apart from pushing the cart, no tasks appear to involve pushing or handling manual materials of large weight for periods of time. Static back flexion is required to perform tasks such as reaching in to deep sinks to clean dishes, or to reach over counter tops to far corners to clean and sanitize (see Fig. 3). Fortunately, tasks that require static back flexion are usually short in duration and intermittent throughout the shift. Working in a standing position for more than 3 hours of a shift is a possible contributor to low back soreness and overall fatigue. A risk identification checklist was used in conjunction with observations. Please see Appendix I for general recommendations.

Force measures show that the force required to push the food cart is below recommended allowable load limits in Snook Tables (Snook and Ciriello 1991). Snook Tables are guidelines based on one person pushing, and do not consider other factors that may reduce one’s ability to push. In Enderby, two people push the cart, which would allow the limits presented in Snook Tables to be increased even further for a two person push (rough estimation based on the assumption that both FSWs push equally).

OHSAAH compared Snook Table recommendations to forces required to push the cart. Forces were found to be below recommended maximum allowable load limits. This does not preclude risk of injury or associated fatigue when pushing and maneuvering the cart - it merely suggests that according to ergonomic guidelines, the pushing task itself is not above recommended limits (Snook and Ciriello 1991).

Although the pushing forces are below allowable limits, there is still concern about the forces required to maneuver the cart. It should be understood though that a motorized “push-puller” is generally best utilized when high force is manually exerted to push a cart, there is plenty of room to operate a cart, and environmental conditions for operating are optimal. In Enderby, the force required to push the cart is not excessively high, and more importantly, there is not a lot of room to operate the cart (especially around corners). As well, environmental conditions in the winter make it potentially hazardous to operate machinery in a constricted and possibly slippery area. A motorized “push-puller” may be difficult to maneuver through confined areas of the pathway due to the additional length of the load, and transfer time may substantially increase due to details such as attaching, detaching and properly storing the “push-puller” after each use. Operating a
motorized “push-puller” also requires the operator to wear steel toed boots at all times (FSWs currently wear running shoes).

If a motorized “push-puller” were used, two workers would still be needed to maneuver the cart inside the Enderby building because the existing cart is hard to steer with only one person. Once outside, transferring would require only one operator instead of two because the motorized “push-puller” would replace the other FSW. Also, the frequency and duration of pushing the cart from Enderby Hospital to Parkview Place is low. Automating the task with “push-pulling” machinery addresses only the issue of pushing the cart, rather than the sum of all the risk factors.

In a recent trial evaluation of a motorized “push-puller” in Vancouver, it was apparently noted that some of the subjects who used the piece of equipment reported some upper extremity discomfort. This raises the question as to whether or not the motorized “push-puller” poses other risk factors for the development of cumulative injuries. The results of this trial are still being processed, and therefore cannot be cited at this time. We await these results.

A motorized “push-puller” might alleviate some issues, but not address the main issue, the maneuverability and design of the food cart. The physical constraints of the path, poor environmental conditions for several months of the year, and the relatively infrequent and short time required to push the cart make it questionable as to whether a motorized “push-puller” would be of the most benefit to staff. The addition of a motorized “push-puller” to the size of the existing cart would make it much more difficult to maneuver around the corners of the ramp and through the gates. Taking all of the above factors into consideration, a motorized “push-puller” may not be the best solution for Enderby Hospital. The effort it takes to push and maneuver the current food cart up the ramp and around corners, however, is still of concern.

A cart that is lighter and easier to maneuver would help to reduce risk of injury from pushing the cart. The following list is an example of changes that might be incorporated into cart design to improve the cart and thus working conditions:

**Minimal Specifications for Cart Design:**

- A shorter and narrower cart may be easier to maneuver, and would fit through doorways and gates more easily.
• Properly designed casters and larger wheels (with properly sized and protected screws) may also increase maneuvering ability and safety.
• Wheels with traction appropriate for winter weather would help to reduce sliding and maneuverability problems in ice and snow.
• Two swivel wheels (rear) and two fixed wheels (front), instead of the current four swivel wheels, would improve maneuverability and reduce the twisting forces required to steer.
• Sealed pre-lubricated precision ball bearings are recommended for hand-push trolleys that are used over short distances.
• One bigger insulated box would hold just as much food as the existing three smaller boxes and would be lighter. (Each existing box weighs 27 lbs, totaling 81 lbs of insulated box weight alone.)
• Raising the height of the boxes to an appropriate height for workers would decrease the back flexion required to add and remove food.
• Minimizing cart weight – i.e. replacing the bottom sheet of metal with strong wire mesh would reduce the entire weight of the cart.
• A handbrake on the back of the cart would decrease the effort required to control the speed of the cart when going down the ramp.

Job Rotation:
Redefining each position’s frequency of cart pushing to evenly distribute pushing tasks and reduce cumulative loads is a form of job rotation that would reduce exposure to the task. For example, a person working in Position #5 could have their pushing duties reduced to once per shift by having another person that does not currently push take a turn. Alternating pushing duties with staff at Parkview Place would be another way of reducing pushing duties of Enderby staff. (It is recognized that though task rotation in the existing system may help to reduce cumulative strain for individual workers, this method does not reduce the absolute risk of injury - i.e. slips and falls.)

Recommendations:
1) Purchase, remodel or design a new cart to minimize risk of injury from pushing and maneuvering.
2) A future assessment with Enderby Hospital to ascertain that the implemented approach is effective, including evaluation over a one-year period, a staff survey, a survey assessing perceived exertion or postural discomfort, force measurements and a biomechanical analysis.

Conclusion:
An ergonomically designed cart is deemed the most suitable way of reducing the risk of injury to FSWs when pushing the food cart. A re-engineered cart design should address the physical constraints encountered in food transfers.
References:


## Appendix I

### Risks and recommendations for Food Service Workers in Enderby Hospital Kitchen

<table>
<thead>
<tr>
<th>Risk</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awkward postures while cleaning equipment</td>
<td>Workers should be made aware of proper body positions and body mechanics while cleaning equipment. Avoid back flexion whenever possible. The arms and elbows should be kept close to the body and postures that require excessive reaching should be kept to a minimum.</td>
</tr>
<tr>
<td>Cutting potato into halves while holding potato in palm of hand</td>
<td>Place potato on cutting board and cut away from the hand (not towards the hand). Ensure handles are properly sized; grip size of knives should accommodate the food service workers (WCB of BC 1994) in Enderby Hospital. As well, knives should be sharpened regularly.</td>
</tr>
<tr>
<td>Peeling potatoes</td>
<td>Recommended posture action values are not exceeded (WCB of BC 1994) because this task is performed for less than 25% of the shift. Nonetheless, keep wrist in neutral position as much as possible. Ensure potato peeler handles are of proper size; grip size of peelers should accommodate the food service workers (WCB of BC 1994) of Enderby Hospital. Use a power grip over a pinch grip whenever possible when holding potatoes; a pinch grip is 5 times more stressful than a power grip (NIOSH 1997). Proper fitting gloves may help to reduce force required to grip slippery potatoes.</td>
</tr>
<tr>
<td>Potato cutting with knife instead of potato peeler</td>
<td>Always use potato peelers to peel potatoes, never use knives.</td>
</tr>
<tr>
<td>Preparing jugs of juice (requires static shoulder abduction to hold containers for mixing concentrate with water)</td>
<td>Place jugs on a lower surface to reduce the amount of shoulder abduction required to hold the container above the jugs. Lean the container over the counter so the counter supports the bulk of the weight (not the worker).</td>
</tr>
<tr>
<td>Removing dish-racks from the tray line requires excessive back flexion and shoulder abduction across the water trough.</td>
<td>Store dish-racks where they are easily accessible. Ensure new storage place reduces excessive back flexion and shoulder abduction, without the addition of new awkward postures.</td>
</tr>
<tr>
<td>Standing for more than 3 hours of total shift</td>
<td>Provide a seat to permit alternate seating and standing. Anti-fatigue mats can also be used on hard floor surfaces, and foot rests allow workers to shift weight, thus reducing muscle demands on the lower back and legs.</td>
</tr>
<tr>
<td>Static back flexion when reaching into far corners to clean and sanitize counter tops</td>
<td>Long handled scrub brushes may allow workers to reach far corners without excessive back flexion.</td>
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