



CANADIAN INSTITUTE
SAFETY, WELLNESS
& PERFORMANCE



CONESTOGA
SCHOOL OF BUSINESS

Improving Design for Ambulances Through an Ergonomic Lens – Lessons Learned

Presenter:

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Research Team:

Bronson Du, MSc.

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Canadian Standard for Paramedic Ground Emergency Response Vehicles and Equipment



Partnership:

- Center of research expertise for the prevention musculoskeletal disorders (CRE-MSD)
- CSA Group (Canadian Standards Association)
- Paramedic Association of Canada (PAC)
- Paramedic Chiefs of Canada (PCC)
- County of Frontenac
- Dessercom Inc.

Start-End: 01/2017 to 03/2021

Research team:

- CO-PIs: Amin Yazdani, Steven Fischer
- Project Manager: Bronson Du

Project Summary: Establish a Canadian Standard for Paramedic Ground Emergency Response Vehicles and Equipment.

Objective(s): Develop and promote a Canadian Standard that identifies the minimum human factors/ergonomics design and usage requirements for vehicles and equipment with consideration to paramedic and patient safety and infection control. Objectives include:

- Support manufacturers in designing and the procurement of emergency response vehicles and/or equipment in accordance with evidence-based practices;
- Direct paramedics in the safe and responsible usage of vehicles and/or equipment;
- Protect the health, safety & wellbeing of paramedics, and
- Protect public safety by improving patient safety and improving the capacity of emergency responders.

Outcome(s): This study will generate valuable information to facilitate future policy development and allow service providers to understand current methods in developing national standards.

Deliverable(s): The following deliverables signify completion of objectives:

- Environmental Scan, Literature Review and Needs Assessment Technical Reports
- Standards Development publication in both official languages
- Knowledge Transfer by way of a communications plan

Impact(s):

Public Safety and Security actors and communities have access to timely, relevant and credible information and advice. This feeds Canada's Safety and Security systems that are evidence-based, interconnected and resilient.

Today's Webinar

Discuss the research that went into developing the standard:

1. Scoping Review
2. Environmental Scan
3. Key Informant Interviews



Prehospital Emergency Care

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Existing Science on Human Factors and Ergonomics in the Design of Ambulances and EMS Equipment

Bronson Du, Michelle Boileau, Kayla Wierts, Sue Hignett, Steven Fischer & Amin Yazdani





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Exploring the need for and application of human factors and ergonomics in ambulance design: Overcoming the barriers with technical standards

Bronson Du^a, Michelle Boileau^{b,c}, Kayla Wierts^{b,d}, Stephanie Beatrix Karch^{b,d}, Marcus Yung^a, Steven Fischer^{b,c}, Amin Yazdani^{a,b,d,e,*}

Background

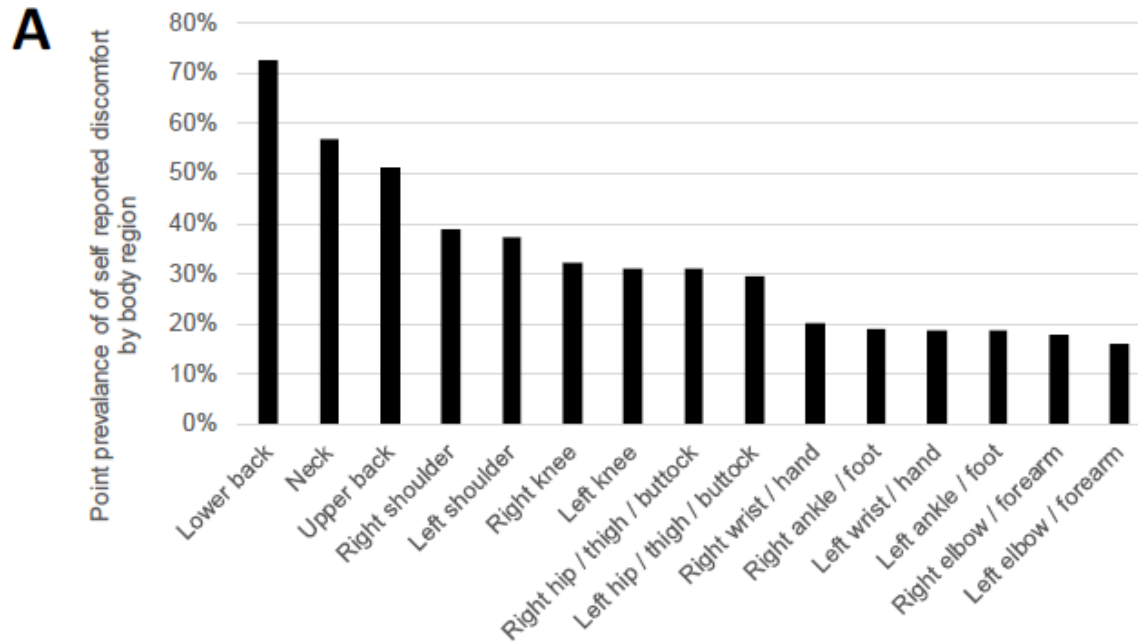
- Over 30,000 paramedics in Canada
- 44.1% of paramedics reported chronic pain in a Canadian-wide survey
 - Lower back: 28.9%
 - Shoulder: 21.5%
 - Neck: 18.1%
 - Leg: 15.0%
 - Arm: 12.5%
 - Foot: 12.2%
 - Hand: 12.0%
- Over 50% of paramedics reporting chronic pain indicated that the pain was associated with an injury related to active duty.



Canadian paramedic health and wellness project

Workforce profile and health and wellness trends

Steven L. Fischer, PhD, RKin, CCPE
Renée S. MacPhee, PhD
University of Waterloo



Sources of Injuries

- Physically demanding tasks
 - Transferring patients from bed to stretcher
 - Lifting and carrying patients on stretchers, stairchairs or backboards
- Prolonged sedentary time to sudden high physical demands (Coffey et al., 2016)
- Body motions were the most common source of injury
 - 90% attributed to lifting, carrying, or transferring a patient and/or equipment (Reichard et al. 2017)

Design is modifiable.

Source of Injuries (cont.)

Traditional Layout

- Cot positioned in the center of the patient compartment
- Rear-facing airway attendant seat at the head of the cot
- Side-facing squad bench on the curbside wall
- CPR seat and cabinets on the roadside wall



Scoping Review

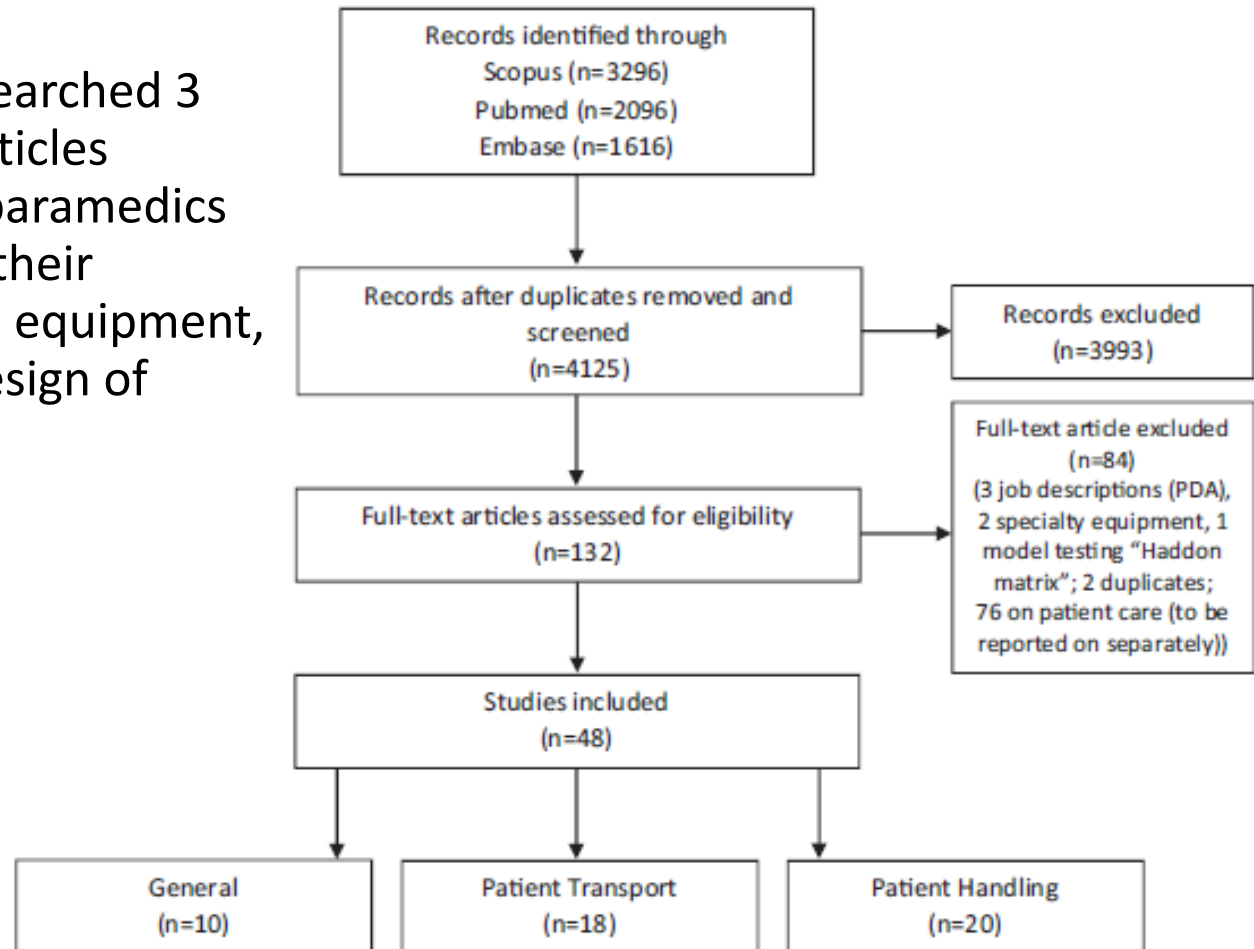
Objectives

- Identify the state of research pertaining to ergonomic interventions or design features for patient compartments or its related equipment
- Identify the design gaps, recommendations, and factors to consider for the patient compartment and its related equipment that is mentioned in the scientific literature

Scoping Review

Methods

- Systematically searched 3 databases for articles related to how paramedics interacted with their ambulances and equipment, as well as the design of these products



Scoping Review



General (n=10)

- Compromising ambulance and equipment designs contributed to the high rates of injury
- 8 articles mentioned the need to develop better design standards

Scoping Review

Patient Handling (n=20)

- Some effective interventions



Cots (n=9)



Backboards (n=2)



Loading systems (n=2)



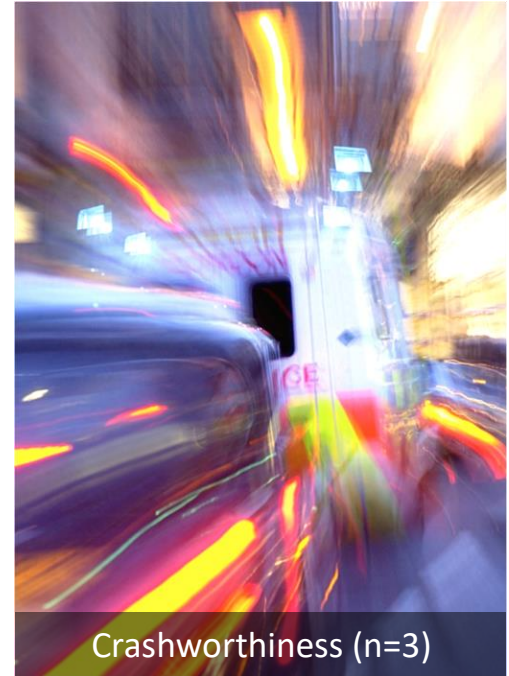
Stair chairs (n=4)

other patient handling accessories (n=8)

Scoping Review

Patient Transport (n=18)

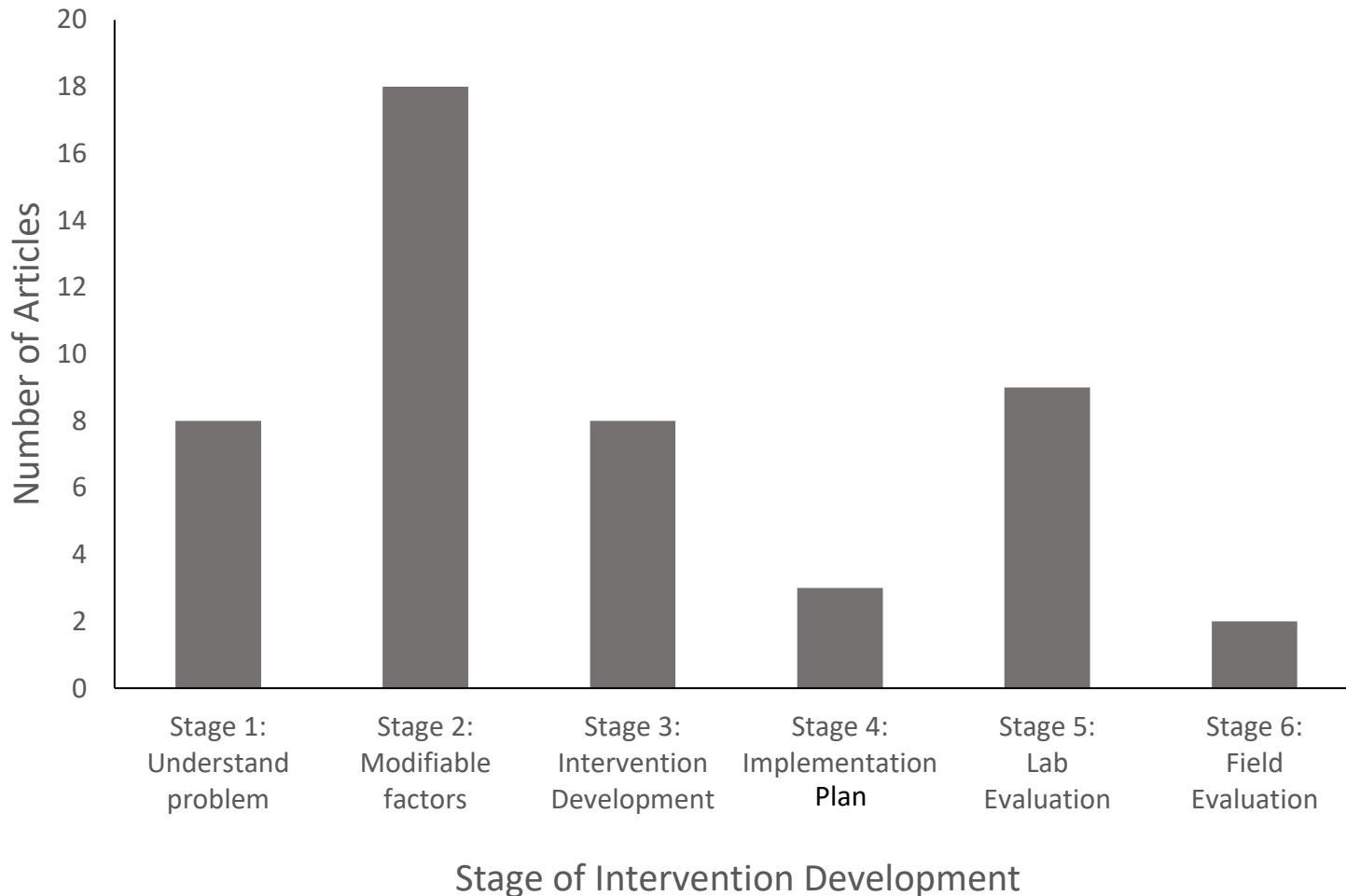
- Providing patient care during transport was unavoidable
- Holistic approach recommended to ensure that all components worked synergistically



Scoping Review

Literature based on the

6 Steps to Quality Intervention Development (6SQuID)



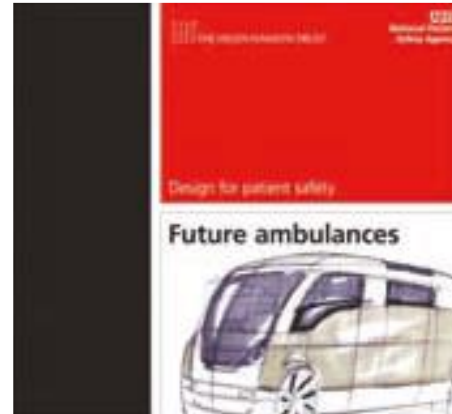
Key Takeaways

- Identified core ergonomic challenges and recommendations for ambulance and related equipment design
- Identified multi-phase projects that underwent several stages of intervention development

Scoping Review: Highlighted Initiatives

Helen Hamlyn Centre for
Design (UK, 2005 - 2011)

- Develop a more efficient and coordinated ambulance procurement process through standardisation of ambulance and equipment designs
 - Consultation with stakeholders
 - 3 iterations of scenario testing



Redesigning the Emergency Ambulance

Improving Mobile Emergency Healthcare



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Scoping Review: Highlighted Initiatives

National Institute for Science and Technology (US, 2011- 2015)

- Help to address safety, comfort, functionality and user-friendliness of the patient compartment
 - National survey
 - Requirements analysis
 - Digital human modelling

Ambulance Design Survey 2011: A Summary Report

Y. Tina Lee, Deogratias Kibira, Allison Barnard Feeney, and Jennifer Marshall

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Procedia Computer Science 16 (2013) 601 – 610

Procedia
Computer Science

Conference on Systems Engineering Research (CSER13)
Eds.: C.J.J. Paredis, C. Bishop, D. Bodner, Georgia Institute of Technology, Atlanta, GA, March 19-22, 2013.

Requirements Analysis for Safer Ambulance Patient Compartments

Mehdi Dadfarnia, Y. Tina Lee, Deogratias Kibira, and Allison Barnard Feeney

National Institute of Standards & Technology, 100 Bureau Drive, Gaithersburg, MD 20899, USA

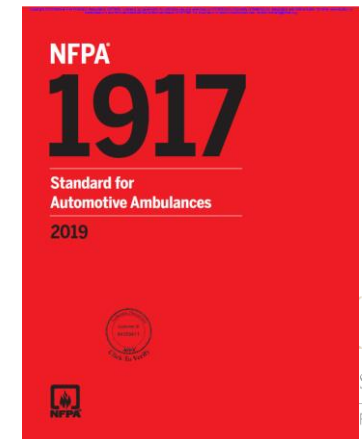
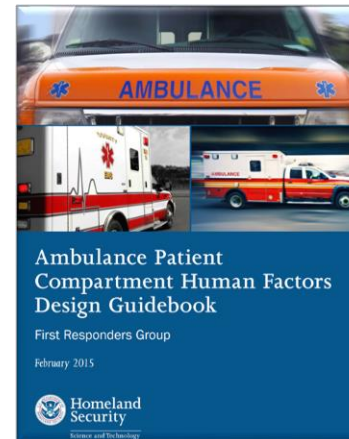
Simulation

Medical Simulation

**Simulation-based design concept
evaluation for ambulance patient
compartments**

Simulation: Transactions of the Society for
Modeling and Simulation International
2013, Vol. 91(8), 691–714
© 2013 The Author(s)
DOI: 10.1177/00375497135092716
sim.sagepub.com
SAGE

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Scoping Review: Highlighted Initiatives

Human Factors Team in Alberta Health Services and W12C Research and Innovation Centre (Can, 2012 – 2019)

- Inform the standardization of a provincial ground ambulance fleet
 - Interviews and focus groups
 - Simulated scenarios
 - Observations

Human Factors Review of EMS Ground Ambulance Design

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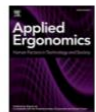
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The evaluation of an ambulance rear compartment using patient simulation:
Issues of safety and efficiency during the delivery of patient care



Greg Hallihan^a, Jeff K. Caird^{a,b,c,*}, Ian Blanchard^{c,d}, Katelyn Wiley^{a,b}, Jessica Martel^{a,b},
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^d Emergency Medical Services, Alberta Health Services, Canada

feature

Human Factors Guidelines for the Design of Mobile Medical Environments

Patient care in mobile environments, such as air and ground ambulances, presents challenges that can be addressed through vehicle interior design and layout.

By Jessica Jones, Katherine Bubric, Susan Biesbroek, & Jason Laberge



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Environmental Scan

Objectives

- Identify the extent of ergonomics considerations in existing ambulance design standards

Environmental Scan

Methods

- Web-based search of government websites to retrieve provincial and territorial ambulance design standards, regulations and guidelines

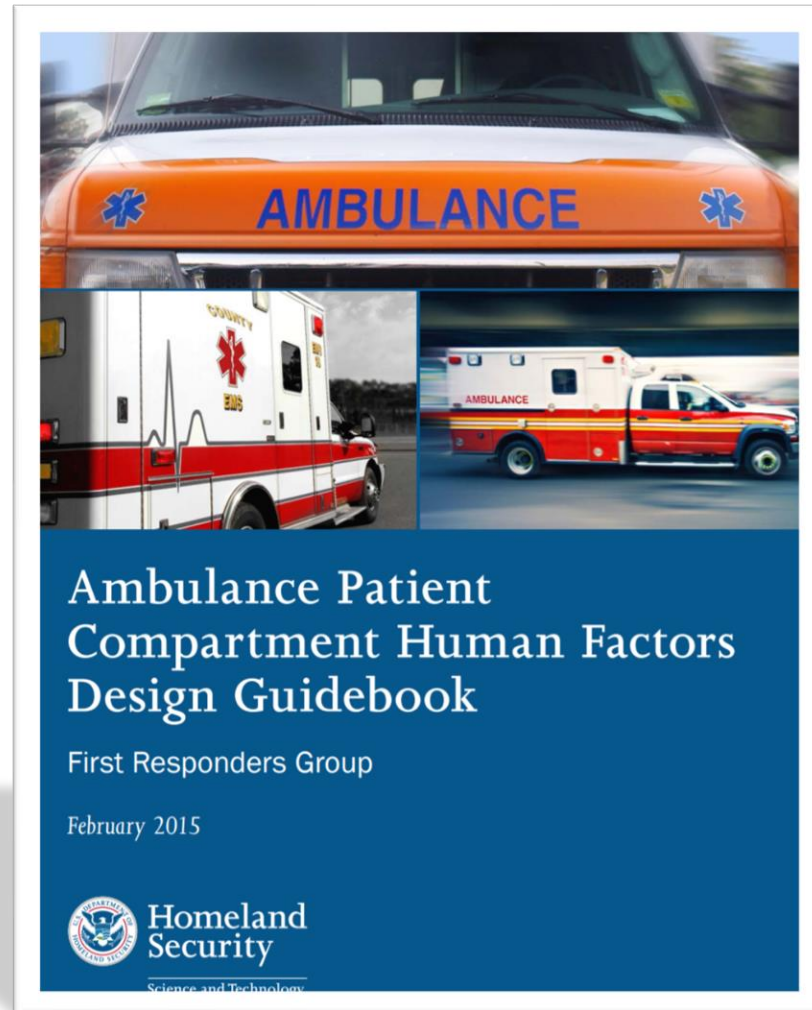
Province/ Territory	Standard	Date
BC	WorkSafeBC OHS Guidelines Part 3, First Aid Supplementary Materials - Emergency Vehicles and Equipment	Accessed 2017
AB	Ambulance Vehicle Standards Code	2010
SK	The Ambulance Regulations	2009
MB	Land Emergency Medical Response System Regulation	2015
ON	Ontario Provincial Land Ambulance & Emergency Response Vehicle Standard v4.1	2010
QB	BNQ 1013-110: Ambulances – Vehicles Specifications 2 nd edition	2014
NL	Consolidated Newfoundland and Labrador Regulations 965/96 - Motor Carrier Regulations under the Motor Carrier Act (O.C. 95-611)	2006
NB	New Brunswick Provincial Land Ambulance Conversion Specifications	2017
NS	Commission on Accreditation of Ambulance Services, Ground Vehicle standard for Ambulances.	2015
PE	Ambulance Services Act General Regulations	2013
YT	N/A	N/A
NT	N/A	N/A
NU	N/A	N/A

Extraction of relevant ergonomic information

Design Considerations

- Seating and restraints
- Cots
- Storages
- Ingress and egress

Location Considerations



Environmental Scan

Number of standards that considered the **DESIGN** of each component

	DESIGN CONSIDERATION	BC	AB	SK	MB	ON	QB	NL	NB	NS	PE	Σ
Seat & Restraints	Seating		X			X	X	X	X	X	X	7
	Restraint system		X	X		X			X	X	X	6
	Equip each position with restraints		X	X		X	X		X	X		6
	Headroom	X				X			X	X	X	5
	Bolsters		X			X			X			3
	Design seating for cleaning						X		X			2
	Transport of children		X									1
Cots	Retention system		X		X	X	X	X	X	X	X	8
	Cot design		X	X	X	X	X	X			X	6
	Restraints	X			X	X		X				4
	Loading					X						1
Storage	Adequate storage space		X	X		X	X	X	X	X	X	8
	Equipment retention		X	X		X	X	X	X	X	X	8
	Trash and sharps		X		X	X	X		X	X	X	7
	Storage cabinets, doors, and drawers		X	X		X	X		X	X		6
	Labeling and identification					X	X		X	X		4
	Consistency and organization									X		1
Ingress/Egress	Personal belonging						X					1
	Emergency egress		X	X		X	X	X	X	X	X	8
	Doors		X	X		X	X	X	X	X	X	8
	Steps		X			X	X	X	X	X	X	7
	Windows		X			X	X	X	X		X	6
	Handholds/handrails		X			X	X		X	X		5
Ingress/egress of occupants and equipment		X	X							X		3

Environmental Scan

Number of standards that considered the **LOCATION** of each component

Location Consideration	BC	AB	SK	MB	ON	QB	NL	NB	NS	PE	Σ
Doors		X	X		X	X	X	X	X	X	8
Seats		X	X		X	X	X	X	X	X	8
Lighting		X	X		X	X	X	X		X	7
Main cot		X			X	X		X	X	X	6
Cabinetry		X	X			X	X			X	5
Action wall		X			X	X		X	X		5
Grab handles		X			X	X		X	X		5
Iv holders			X			X	X	X	X		5
Oxygen outlets		X			X	X		X	X		5
Side door step		X			X	X		X	X		5
Rear step bumper		X			X	X		X	X		5
Suction systems					X	X		X	X		4
Spare tire					X	X	X	X			4
Bolsters		X			X			X			3
Sharps container						X		X	X		3
Fire extinguisher					X	X		X			3
Other patient handling equipment						X		X			2
Incubator receptacles					X			X			2
Restraint net		X									1
Fuses and breakers								X			1
Radio mounting					X						1
Clocks								X			1

Key Takeaways

- Standards have not been used as a tool to communicate ergonomics
- Many existing standards provided general minimum requirements, but lacked a meaningful and testable criteria for functionality
 - No guidance to assess functionality of the patient compartment as a whole

Key Informant Interviews

Objectives:

- Understand how existing standards and ergonomics were applied in the ambulance design and procurement processes
- Explore the barriers of applying ergonomics into ambulance design

Key Informant Interviews

Methods:

- Semi-structured interviews with key informants
 - Paramedic chiefs
 - Manufacturers
 - Front-line paramedics
 - Fleet supervisors
 - Procurement professionals

Sample question:

- *“Step by step, tell me about the process of purchasing (or designing) an ambulance.”*

Use of ambulance design standards

Manufacturers' use of standards

- Designed to the highest standards to meet multiple standards and tend to multiple markets
- Performance testing procedures were similar between jurisdictions, but threshold values and certification process varied

"If we're kind of making a generic truck, we'll test it to a lot of the Ontario standards. Because we know if it meets that, it's going to meet the other ones."

- Manufacturer

Purchasers' use of standards

- Used standards in request for proposals but additional requests for ergonomics were rarely made
- Relied on the ambulance standards and the ambulance manufacturers for quality, safety and functionality

"...it's a little bit lax in [name of province] for sure. So, I think they kind of let the onus be on the manufacturer for meeting some sort of recognized ambulance standard."

- Manufacturer

Key Informant Interviews

Barriers to integrating ergonomics into ambulance design:

1. Lack of mandate for ergonomics
2. Lack of market demands
3. Limited options
4. Financial disincentives

Key Informant Interviews

Barriers

1. Lack of mandate for ergonomics

- Standards were patient-centered, rather than user-centred
- No governing body for ergonomically certified products
- Manufacturers relied on limited available ergonomic guidelines

*“...all these **standards and requirements are targeted towards patient care, it’s not targeted towards how to make our job easier. It’s not built for the ergonomics of paramedics, it’s built for safe patient care... But, you know, if they can add in things like certain equipment needs to have this kind of weight restriction or... it has to have certain restraint systems build in to help [make] it easier to be restrained in the back of the ambulance that would really make our job a lot easier or safer too.”***

- Paramedic

“Really, what is ergonomics, how do you define ergonomics?... There’s no governing body.”

- Procurement

“We rely on whatever information is out there by industry acceptable terms.”

- Manufacturer

Key Informant Interviews

Barriers

2. Lack of market demands

- Ergonomics not set as a priority in the request for proposal
- Other than ergonomics, factors including costs, vehicle serviceability, durability, and fleet compatibility needed to be considered

“There’s absolutely nothing in regards to ergonomics, zero. So when you look at the... evaluation sheet... it’s basically 100 points. And out of that 100 points say 50 percent of it has to do with cost, and then 20 percent may have to do with professionalism or service or, 10 may have to do with delivery. There’s nothing in there that would change the manufacturer to change their specs let’s say.”

- Procurement

Key Informant Interviews

Barriers

3. Limited options

- Purchasing ambulances was a process of elimination
 - After fulfilling other key criteria such as identifying the provincially certified ambulance models and selecting the ambulance type/size, options became limited

“We’re really limited because being certified by the ministry there was only, like I said, one or two [ambulances] that you could choose from.”

- Manager

Key Informant Interviews

Barriers

4. Financial disincentives

- Clients had to cover the costs of recertifying customizations to a standard ambulance model

*“[One paramedic service], for example, redesigned the interior of one of their ambulances and for them to do that, **[they] bore the whole cost of the certification of that vehicle** because that’s what they wanted. So, if all of a sudden, I wanted to do the same thing, I wanted to put a different seat with a five-point harness, I would have to pay the full cost of the test and the certification by the ministry for them to actually put that seat in. So, that being said...You know, **that’s an additional cost to me on top of the value of the ambulance and it’s really not cost effective for me to change anything that’s not offered.**”*

- Procurement

Key Takeaways

- Ergonomics has not been championed by the existing standards or key stakeholders
 - Onus for considering ergonomics was shifted to ambulance purchasers and manufacturers
- Many ambulance services did not sufficiently communicate their ergonomic needs in the request for proposal
 - Other factors such as type/size of ambulance, serviceability, fleet compatibility, payload, fuel efficiency, and costs were prioritized

Conclusion

- Inclusion of ergonomics into standards would:
 - Take the onus off of the purchasers to establish additional ergonomic customizations beyond those established by existing standards
 - Enable designers to meet core ergonomic principles during product development
 - Reduce the need for designers to rely on their knowledge or desire to review scientific papers in ergonomics

“...whereas many organizations pay little regard to research findings, few can afford to ignore standards.”
– Tom Stewart

Core Research Team



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 - Stephanie Karch



Questions and Answers