Safe evacuation of different groups of (vulnerable) hospital patients

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Graduation presentation
CONTENT

1. CONTEXT
2. RESEARCH QUESTION
3. RESEARCH
4. DESIGN TOOL
5. CASE STUDIES
6. CONCLUSION
CONTEXT
- Hospitals are complex buildings with several high risks

- Dependent patients who need assistance during evacuation

- 1000 fires in Dutch health care premises each year

- Major causes are faulty or misuse equipment, arson and smoking
Current regulations

- Based on **old principles** of health care

- Based on larger patient rooms

- Corridors only used as **traffic space**

- Horizontal evacuation only required in one direction
Changing design trends

- Shifting towards “Healing Environment”
- Smaller individual patients rooms
- Corridors which serve as living room
- Increase of fire risks and fire load which leads to lower ASET (Available Safe Egress Time)
Changing use

- **Limited staff** available due budget restrictions

- Patient population is changing, increase of *complex patients* on all wards

- **More equipment** must be disconnected

- Increase of **RSET**
  (Required Safe Egress Time)
Fire test in patient room
RESEARCH QUESTION
What design guidelines can be derived for a fire safety concept in hospitals that matches new design trends, actual use and corresponding egress times of vulnerable patients?
RESEARCH
OBJECTIVES

Existing research

- Overview of available data on egress time of different groups of vulnerable people

Missing:

- No data available for the actual disconnecting and evacuation times for specific patients

- Designs focussed on the required safe egress time of a ward and the actual risks
Specific parts of evacuation

- Arrival speed
- Leaving room
- Evacuation speed
- Passing fire door
- Descending stairs
Average uncoupling & disconnecting times

Basic patient  Standard patient  Dialysis  Recovery  Heart monitoring  Incubator  Intensive care
Specific parts of evacuation

- Arrival speed: 1,42 m/s
- Leaving room: 9,3 s
- Evacuation speed: 1,23 m/s
- Passing fire door: 7,4 s
- Descending stairs: 3:19 m
Specific parts of evacuation

- Arrival speed
- Leaving room
- Evacuation speed
- Passing fire door
- Descending stairs

3:19 m
Average uncoupling & disconnecting times

5.5 s  30.1 s  15.3 s  28.5 s  33.5 s  46.0 s  89.2 s

Basic patient  Standard patient  Dialysis  Recovery  Heart monitoring  Incubator  Intensive care
Average uncoupling & disconnecting times

- Basic patient: 5.5 s
- Standard patient: 30.1 s
- Dialysis
- Recovery
- Heart monitoring
- Incubator
- Intensive care
Average uncoupling & disconnecting times

<table>
<thead>
<tr>
<th>Basic patient</th>
<th>Standard patient</th>
<th>Dialysis</th>
<th>Recovery</th>
<th>Heart monitoring</th>
<th>Incubator</th>
<th>Intensive care</th>
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Influence of trained staff

- Improvement of evacuation times during experiments
- Time necessary for coordination and discussion
- Doors remain open

**Influence of trained staff in uncoupling specific patients**
DESIGN TOOL
ARCHITECTURAL ELEMENTS

PRESENCE OF STAFF

TRAINING

Design approach developed
Fill in design tool

- Safe design in 9 steps
- Data applied
- Comparable results
Calculations

Probability calculations

Average RSET of ward = \[
\text{Response time [s] + Extinguish attempt [s] + (Evacuation time per patient [s] x Number of patients)}
\]

Egress time calculations

Staff present + (extra staff - arrival time [s]) + (extra staff - arrival time [s]) + ...
Results

Relative risk
- Calculated risk for new design
- Calculated risk for layout based on current regulations
- Risk in % to compare new design

Required Safe Egress Time
- Calculated RSET for new design
- Calculated RSET for layout based on current regulations
- Equal times for comparison
- RSET in seconds
CASE STUDIES
Dialysis & Intensive Care

*Basic layout based on current regulations*

**Current regulations**

- Fire compartment of 500 m²
- No separations if permanent surveillance
DESIGN: CASE STUDIES

Intensive Care

New layout for Intensive Care, split up in 4 compartments
Intensive Care

- Split up in 4 compartments
- 4 staff members direct present

Compartment A
Open compartment with 7 patients
- Actual risks 8,6% directly threatened
- RSET 09:49 [mm:ss]

Compartment B
Single patient rooms with 8 patients
- Actual risks 6,6% directly threatened
  13,8% indirectly threatened
- RSET 11:13 [mm:ss]
New layout for Dialysis, split up in 2 compartments
Dialysis

- Split up in 2 compartments
- 4 staff members present

Compartment A
Open compartment with 20 patients

- Actual risks 34,9% of directly threatened
- RSET 09:23 [mm:ss]

Compartment B
Single patient rooms with 16 patients

- Actual risks 10,8% directly threatened
  34,0% indirectly threatened
- RSET 08:09 [mm:ss]
Fire safe hospitals

Dialysis

Intensive Care
Conclusion

- New layouts based on equal risks and equal required egress times

- Different designs necessary for specific wards

- Current regulations outdated

- Focus on egress time instead of square meters
CONCLUSION
CONCLUSION

**Literature**
- Regulations are outdated
- Problems occurred during fires

**Experiments**
- Behaviour of staff
- Large diversity in uncoupling times

**Design**
- Combination of solutions
- Presence of staff
- Focus on required egress time and risks instead of square meters
RECOMMENDATIONS

Research

- Gathering more data about specific egress times
- Probabilities of problems occurred during fires
- More specific data about causes of fire

Design

- Equal risks and egress times for specific wards
- More elaborated link between ASET & RSET
- Designs should be focussed on simple performable evacuations
- Reconsideration of limit values
“Customised designs for specific wards are required to ensure equal risks per patient in hospitals.”

“Adaptable design solutions for a state of the art fire safety concept that matches new design trends, actual use and corresponding egress times for different groups of (vulnerable) patients.”
Thank you!