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AN ARCHITECTURAL WORKFLOW DATABASE FOR GENERATING EVIDENCE-BASED HEALTHCARE FACILITIES' DESIGN VIA TRANSFER LEARNING

Julia Zieleniewska[1] and Dimosthenis Kifokeris[2]
[1]Poznan University of Technology, Poznan, Poland
[2]Chalmers University of Technology, Gothenburg, Sweden

Abstract

Evidence-based design (EBD) principles can help overcome legislative shortcomings and long-standing challenges in designing healthcare units. Leveraging these principles through transfer learning can utilize pre-trained knowledge to generate optimal spatial arrangements, yet the dataset-formulating factors remain scarcely investigated. Mixed methods (including workflow analysis and behavioral mapping in an emergency care unit) are employed to generate a highly contextual EBD database. Using four actor flow scenarios, dead zones, nodes, collision points, approximate nursing distances, and zone mapping were identified as key contextual factors. This study contributes to informing design considerations and the contextual training of transfer learning in generative healthcare architecture.

Introduction

The emergency department spatial organization affects patients and personnel. ERs play a key role in healthcare systems (Zieleniewska et al., 2026). Comparing Swedish and Polish ERs reveals certain design factors, which mostly originate from evidence-based design (EBD) (Gawlak and Stankiewicz, 2022).

The information base for architectural factors remains fragmented and difficult to transfer between case studies. Machine learning and data-driven methods were proposed for synthesizing a knowledge base. Study aims to propose an architectural approach including combination of workflow, plan analysis and behavior mapping (Grzywiński et al., 2020; Mahmeen et al., 2024) of selected ER, as a method of generating the basis for transfer learning-assisted design space generation. Transfer learning (TL) can be promising for extracting operational and spatial patterns from existing ER layouts.

Research method and materials

Analyzing ERs enables identification of design patterns and transferable data extraction. Employing mixed methods, a literature review (Pruszewicz-Sipińska et al., 2023) and walkthrough analyses (field observations, staff interviews) (Niezabitowska, 2014) were conducted in four Polish and one Swedish hospital case studies. The case selected in this extended abstract comprises the currently under-construction ER extension of a provincial hospital in western Poland, with a daily admission of 200-300 patients and a capacity of 24-30 beds, which features a combined hospital and ER registration impacting the flow of personnel and patients. Due to confidentiality, the unit's name and location are not disclosed. Workflow and behavior mapping were conducted using ArchiCAD29 on plans and via staff interviews. The 2D plans contributed to flow diagrams and critical point analysis. Combined with focus interviews, this served for behavior mapping, revealing scenarios linking rooms and inter-zone flow, establishing action sequencing. For pattern identification, functional zones (registration, medical, urgent, staff), key users, their roles and behaviors were defined. Study was limited to main patient scenarios (Figure 1): short stay, admission, emergency pathways and personnel maintenance. The next step includes creating a visual pathway for users.

Results

The patient flow is mostly linear, while the staff's is mainly circular. Results stemming from the workflow and behavior mapping were identified (Figure 1):

1. Dead zones:
   a. Niches in the foyer - need to verify actual usage through post occupancy evaluation (POE).
   b. The break room is located close, but outside ER; distances may discourage from regular breaks.
2. Nodes:
   a. Corridor bend connecting the urgent track with the rest of the hospital.
   b. Corridor bend connecting the main corridor and the urgent track, limiting distances and clarifying orientation. Possible paths collisions.
3. Collision points:
   a. One large nurse station; better supervision, may generate staff crowding.
   b. Operational disturbance between procurement staff and transported patients
4. Bottlenecks: Registration, triage, transfer corridor

Mapping clarifies context, revealing processes, scalable factors related in circulation, zoning and visibility:

1. Waiting area for both scheduled and emergency patients (risks: chaos, paths collisions)
2. Larger isolation room without access to exterior area: possible problems in the event of pandemic
3. Single observation area: increased supervision

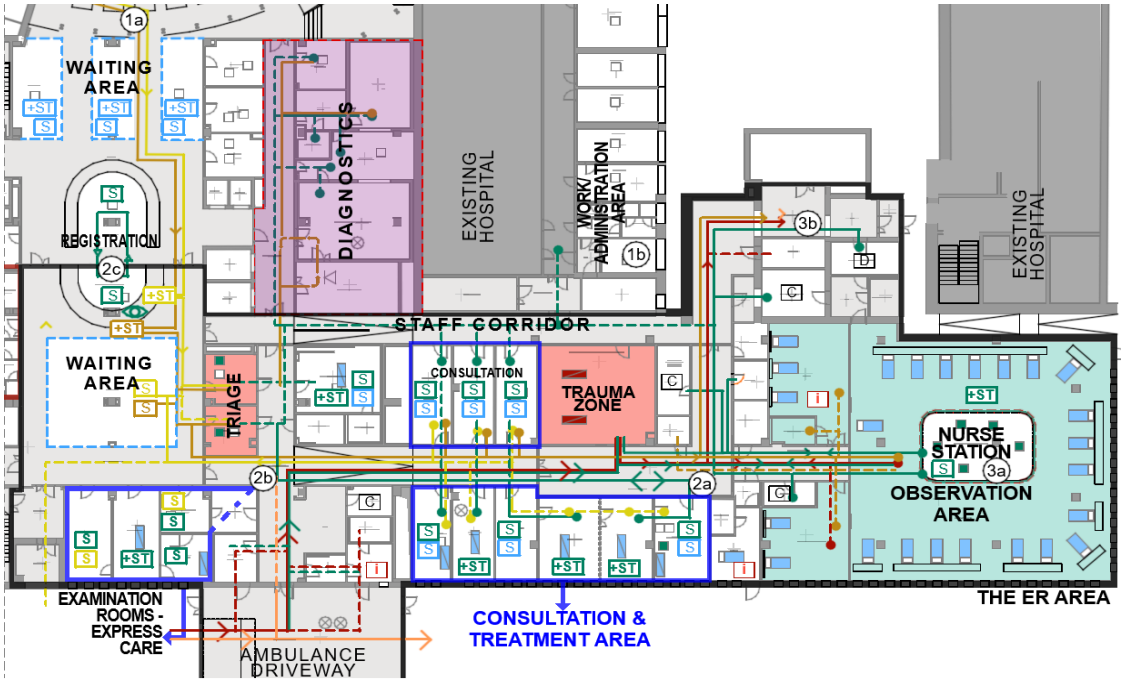

Figure 1: Workflow and behavior mapping (own work). Blue: patients in general; red: urgent patients; yellow: few-hours patients; brown: mild cases; green: personnel; orange: paramedics; navy blue: zones; i: isolation; c: clean storage; d: dirty storage; ST: standing; S: sitting; Alternatives: dashed. lines.

4. Trauma zone nearby observation: quick transfer.
5. Diagnostics located nearby reduce distances
6. Separate express care eliminates unnecessary patient influx into medical zone.
7. Nursing distances: ~38m (staff corridor), ~41m (main corridor, urgent part: ~35m), ~44m (triage to observation room). Communication covers ~26% of the area.

Discussion – transfer learning

Transfer learning may address the limited generalizability of ER layouts, using workflow mapping data as structured input for relational patterns (Khodaee et al., 2024) and decision-making. Mapping methods, coupled with normative knowledge can form a hybrid training dataset for transfer learning: relational determinants compatible with graph-based models, sequence learning, and hybrid-symbolic systems (Rahbar et al., 2022), supporting transferability and replicability.

Conclusions

ERs' spatial organization shapes clinical performance and patient experience. Workflow reveals spatial issues and supports structured data for TL-assisted design.

The main limitation is that ER is under construction. Future studies should include POE using live tracking. Kernel density analysis may support further investigation of contextual factors not examined at this stage.

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