Personnel Fluctuation in Austrian Emergency Medical Services: A Data Visualization Approach

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Abstract

Emergency medical services in Austria rely on the work of EMTs (Emergency Medical Technicians), most of whom contribute on a voluntary basis. According to domain experts, it is necessary to maintain a structured overview of EMT fluctuation to ensure adequate medical care in the region. The fluctuation of EMTs can depend on various factors, making it difficult for station commanders to retain EMTs. Domain experts have stated that the reasons an EMT exits an ambulance station can often be addressed if identified early. Possible exit factors and remedies are typically discussed in a yearly meeting between each EMT and the station commander. Still, experts note that fluctuation factors can be overlooked or incorrectly assessed during these meetings. Therefore, this work presents a visualization approach for EMT fluctuation data and evaluates whether it can support station commanders. Visualizing which EMTs did not fulfill the minimum number of shifts in the last 12 months, and whether they completed those shifts at another station, should provide the commander with a better basis for the yearly meeting with each EMT. A retention strategy mentioned by the domain experts is to offer shifts with colleagues the EMT completes the most shifts with. For this reason, a list of "clusters" of EMTs is created, showing the five EMTs a person shares the most shifts with, as well as a visualization whether the EMT prefers emergency or transportation shifts. The visualization approach follows the design study methodology and involved two interviews with domain experts from a rural ambulance station in Lower Austria. The visualizations were created by comparing suitable visualization methods and using the Tableau tool for implementation. These include a mosaic-like visualization, a lollipop chart, a slope graph, and a highlight table. The visualizations were presented during a second interview, which led to new findings from the domain experts. The results indicate that visualizing personnel fluctuation can be helpful and enables commanders to better understand and address turnover. According to the domain experts from an ambulance station in Lower Austria, the visualizations are considered useful.

Keywords

Information visualization, dashboard, emergency services

1. Introduction

The healthcare system in Austria considers emergency medical service providers, i.e ambulance services, as part of the prehospital care system. The availability of enough emergency medical technicians (EMTs) is a prerequisite. But their number can be subject to large fluctuation, because most EMTs contribute on a voluntary basis. Although the Austrian Red Cross gained volunteers in recent years, it experienced a decline in voluntarily worked hours. According to its annual reports for 2021 and 2022 [1, 2], the number of volunteer EMTs increased from 74,804 in 2021 to 75,401 in 2022. However, the total number of voluntarily worked hours decreased significantly during the same period, from 12.5 million hours in 2021 to 10.4 million hours in 2022. As Steinheimer [3] stated, in the future, no provider can continue to regard personnel as interchangeable or as pass-through factors.

Domain experts with expertise in management of rural ambulance stations have expressed their interest in a visualization dashboard of their staff and their service shifts in order to better understand the situation in their organization. They intend to use such visualizations to become aware of potentially leaving EMTs and retain them by better accommodating shifts to their preferences.

Conducting problem-driven visualization research, this work presents a visualization dashboard that was designed for an ambulance station in Austria. Following design study methodology [4], it reports

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on the (1) problem characterization using interviews and analysis of the available data, (2) design and implementation of the dashboard in Tableau, and (3) evaluation of the dashboard's utility. All steps were conducted with real-world data in tight collaboration with an ambulance station in a rural Austrian region. Yet, this approach to prevent fluctuation through visualization of shift data can also be applied to other sectors.

2. Background on Ambulance Organizations in Austria

Austrian law regulates EMT certification. Becoming an EMT in Austria involves 140 hours of theoretical and 160 hours of practical training. According to § 50, section 2, sentence 2 of the SanG, EMTs must complete 16 hours of training and recertification every two years, including a CPR demonstration in front of a doctor, to extend their authorization to serve [5].

There are four types of EMT service roles at the Arbeiter-Samariter-Bund Österreichs and the Austrian Red Cross. These roles differ in terms of commitment and duration, and individuals can switch roles, for example from a volunteer to a full-time EMT. According to the Zivildienstserviceagentur, many civilian servants ("Zivildiener") continue as volunteers after their compulsory service. The service types are:

- **Full-time EMT**
  Employee – duration according to contract
- **Civilian Servant ("Zivildiener:in")**
  Compulsory, alternative to military service – 9 months
- **Voluntary Social Year**
  Voluntary full-time work – 10 months
- **Volunteer**
  Unpaid contribution of time – open-ended

3. Methodology

This section presents the methods applied in this study. The corresponding results can be found in the Results section. It begins by presenting the data, which serves as the basis for the subsequent analysis, storage, and abstraction steps. This section also describes the interviews, the process of identifying suitable visualization types, and the creation of the visualizations.

3.1. Presenting the Available Data

The "Objekt ID" column contains membership numbers for EMTs, where "P" denotes a person and "E" a full-time EMT who volunteered elsewhere. Ambulance vehicle data is marked with "M." The "Ressource" column links names to membership numbers and includes designations such as shift managers ("DF" prefix) and district operations commanders ("EL" prefix). "Ausf." represents the number of rescue operations, "h" indicates the duration of the shift, and "Beginn" to "Ende" represent shift start and end times. "Verwendung" refers to the EMT role, and "Abt." specifies the ambulance station. "Dienstart" classifies the EMT type, including volunteer (EA-RKT), full-time (HA-RKT), Zivildiener (ZD-RKT), or external EMTs (EX-RKT). A shift manager has "F" in the "Objekt ID," while district commanders are marked by "E" and "BEL" in "Verwendung." "A" in the "Objekt ID" indicates supervision shifts, marked as "DA" in "Ressource" and "Verwendung." Each CSV file contains empty columns 1–10 and a "Dien" column that includes shift information. At the end of each EMT's record is a summary row showing the total number of shifts and hours.

3.2. Suitable visualization Types

Creating a visualization is both an artistic and scientific process. While one aspect may take dominance, both must be respected. A visually appealing representation can highlight the most relevant aspects of

the data. The goal is to develop a useful visualization tailored to the rural ambulance station [6].

A poor visualization can suffer from aesthetic flaws, perceptual issues, mathematical inaccuracies, or a combination. This section evaluates visualization types that are both aesthetically pleasing and suitable for the data. A good visualization can confirm prior assumptions and also reveal new, previously unnoticed patterns [7, 6].

Based on a detailed review of the data, visualization types for representing amounts, distributions, and probabilities will be explored. For example, the number of EMTs (and subcategories such as volunteers) can be visualized as quantities. The number of shifts per EMT is also quantitative. Yearly changes can be shown as distributions, and trends in people leaving over time can be shown using probabilities.

3.3. Interview Round 1

The first interview round aims to assess the domain experts' understanding of the fluctuation problem and their familiarity with data visualization. Following Buber and Holzmüller [8], a problem-centered interview method is used, complemented by a semi-structured format to allow spontaneous responses.

Two experts from the rural ambulance station were interviewed: the managing director and the district operations commander [8, 4]. The interviewer began by introducing themselves and the research topic. Background questions about the experts' roles and tenure at the station were asked to contextualize their responses.

To support the problem analysis, questions were asked regarding EMT fluctuation and perceived causes. The goal was to align visualization development with domain insights. Toward the end of the interview, visualization types from Section 4.2 were shown to the participants, who were asked to share their understanding and preferences.

Interviews were conducted individually to encourage open discussion. Audio recordings ensured accurate analysis.

3.4. Implementation of the Visualization Dashboard

The visualization dashboard was created using Tableau, a professional tool based on the Polaris system [9]. Tableau provides a user-friendly environment for creating interactive visualization dashboards and rapid prototyping of different design alternatives.

Four visualizations were developed and combined into two dashboards using Tableau:

- **Highlighted Table:** Visualizes the number of shifts per EMT to identify those at risk of quitting.
- **Slope Graph:** Shows shift activity over time for individual EMTs.
- **Lollipop Chart:** Compares the number of RTW and KTW shifts per EMT.
- **Mosaic Plot-Inspired Visualization:** Displays the distribution of EMT types over time.

These visualizations were created using anonymized data and structured into a **main page** and a **detail page** for interactive exploration. The main page gives an overview of staffing and potential dropouts, while the detail page allows deeper inspection of individual shift behavior.

3.5. Interview Round 2

The second interview assesses how well domain experts understand the visualizations. Two methods are used: the thinking aloud protocol [10] and a semi-structured interview. In the thinking aloud method, participants work with a visualization dashboard while verbalizing their thoughts. Prompts such as "What are you thinking right now?" help maintain engagement [11]. The advantages include quick detection of misunderstandings and insights into why they occur. However, the method may feel unfamiliar to participants and may bias responses toward perceived expectations of the interviewer. The semi-structured interview, as in the first round, provides space for additional feedback. Participants can offer suggestions for improvement and share broader reflections.

4. Results

This chapter presents the outcomes based on the procedures described in the Methods section. It follows the same logical structure: beginning with data preparation, continuing through abstraction and visualization types, and concluding with interview insights and the development of the dashboard visualization.

4.1. Abstracting the Data

To analyze and visualize the shifts of EMTs, data from ten consecutive years were processed. The raw data was stored in separate CSV files, each corresponding to a single year between 2012 and 2021. These files were consolidated into one comprehensive dataset to facilitate a unified analysis.

Python was used for all data preprocessing tasks due to its efficiency in handling structured data. After merging the yearly CSV files, initial cleaning was performed, including removing irrelevant columns and rows that did not pertain to regular EMT shifts. These excluded rows included summary rows, vehicle entries, and shifts associated with supervisory or external personnel. Filtering was performed based on keyword matches and ID prefixes, which allowed systematic exclusion of non-relevant data. An example of the final result can be seen in Figure 1.

Objekt ID	Ressource	Ausf.	h	Beginn	Ende	Verwendung	Abt.	Dienstart	1	2	3	4	5	6	7	8	9	10	Dien
P12345	Name		13:00	02.01.2021 18:00	03.01.2021 07:00	SR1	Department 1	EA-RKT											1
P12345	Name		00:30	03.01.2021 07:00	03.01.2021 07:30	SR1	Department 1	EA-RKT											1
P12345	Name		01:30	03.01.2021 18:00	03.01.2021 19:30	SK1	Department 1	EA-RKT											1
P12345	Name		04:30	03.01.2021 19:30	04.01.2021 00:00	SK1	Department 1	EA-RKT											0
P12345	Name		06:00	05.01.2021 18:00	06.01.2021 00:00	SK1	Department 2	EA-RKT											1
P12345	Name		12:00	11.01.2021 18:00	12.01.2021 06:00	SR1	Department 1	EA-RKT											1
P12345	Name		13:30	6 Dienst(e)				SUMMEN:											6

Figure 1: Example of the data from the ambulance station, containing information about an EMTs shift

Once the data was cleaned, a secondary transformation was conducted to prepare a dataset that linked each EMT to their shift partners. To do so, the dataset was parsed to extract shift details from the year 2021. For each EMT, the system identified the top five colleagues they worked with most frequently. This required iterating over the entire shift dataset, categorizing shifts into KTW (non-emergency) and RTW (emergency) types, and aggregating co-occurrences.

The result was a refined CSV file containing EMTs and their most frequent colleagues, which formed the basis for personal-level insights later displayed on the dashboard.

4.2. Suitable Visualization Types

Various visualization techniques were considered for communicating the findings effectively. These were selected based on their ability to represent quantities, distributions, and probabilities.

Amount visualization: To show how many shifts an EMT performed over time or prior to quitting, visualizations like bar plots and lollipop plots were evaluated. The lollipop plot, being an alternative to the bar chart, was found to reduce visual clutter while maintaining interpretability. This format was particularly appreciated by domain experts for its clarity.

Distribution visualization: To represent how EMT types changed over the years, mosaic plots were identified as suitable. Mosaic plots display the distribution of multiple categorical variables and how they interact. In this context, they show the relationship between year, shift count, and EMT type. The mosaic plot's advantage lies in its ability to provide a compact summary of multidimensional data without overwhelming the viewer.

Slope graphs were also considered to illustrate changes over time for specific individuals or categories. Unlike line graphs, which imply continuity, slope graphs focus on comparisons between discrete points

in time. This makes them useful for emphasizing changes in EMT participation between two points in time.

Sankey diagrams were also reviewed as potential visualizations to show flow relationships, such as how EMTs transition between shift types or roles. However, their complexity and potential for visual noise made them less favourable for this context, especially when clarity and ease of interpretation were key.

4.3. Interview Round 1

The first round of interviews with domain experts, including EMT coordinators and district commanders, was conducted to understand how they interpret trends and what types of visualization would support their decision-making.

The interviews revealed that EMTs often reduce their involvement gradually before quitting. This slow decline is often difficult to detect manually. Many cited personal life changes, or a lack of confidence in professional competence as the main reasons for discontinuing service.

Participants agreed that data visualizations would help identify concerning patterns early. They request visualizations on the last 12 months' shift frequency, ambulance versus patient transport shifts, and top five shift partners. These insights could then be used to provide targeted support, such as training or individual consultation.

In terms of preferred visualization types, the experts preferred visualizations like lollipop diagrams, mosaic diagrams and slope graphs. Mosaic diagrams were favored for their comprehensive information presentation. Probability visualizations were liked but may only show likely dropouts.

4.4. Implementation of the Visualization Dashboard

This section presents the developed visualizations and explains how they were combined into an interactive dashboard aimed at supporting domain experts in analyzing EMT personnel trends and potential dropout risks.

4.5. Visualization Components

Highlighted Table The highlighted table identifies EMTs who did not meet the minimum required number of shifts in a given year. This view supports early detection of individuals who may be at risk of quitting. By using filters for year and shift types, only regular (non-special) shifts are considered. Color highlights help domain experts quickly identify those with critical shift shortfalls.

Slope Graph The slope graph (Figure 2) visualizes the number of shifts completed by a selected EMT across each month within a specific year. It also shows at which rural ambulance station the shifts were performed. This enables domain experts to spot trends, such as declining participation or sudden drop-offs, which may signal disengagement or logistical changes.

Lollipop Chart The lollipop chart (Figure 3) compares the number of shifts an EMT completed on two types of vehicles: RTW (emergency response) and KTW (non-emergency patient transport). This comparison can offer insights into EMT preferences or operational role assignment. Displaying the data side by side helps identify imbalances or patterns that could influence satisfaction and retention.

Mosaic Plot-Inspired Visualization The mosaic-inspired visualization displays how the composition of EMT types changed over time, from 2012 to 2021. It shows both relative proportions and absolute numbers for volunteer EMTs, full-time EMTs, Zivildiener, and those performing a voluntary social year. This high-level overview helps contextualize broader staffing trends and the evolving balance of workforce categories.

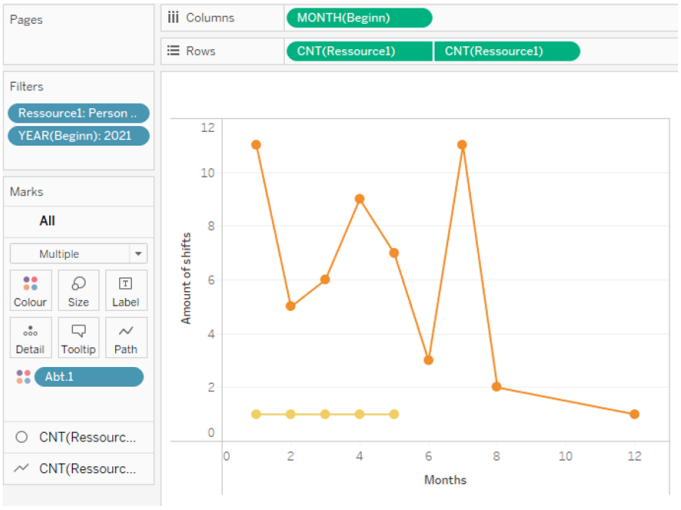

Figure 2: Slope Graph showing monthly shift activity and station distribution for a selected EMT

Figure 3: Lollipop Chart comparing the number of RTW and KTW shifts for each EMT

4.6. Dashboard Integration

The individual visualizations were integrated into two linked dashboard pages designed for both exploration and decision-making.

Main Page As shown in Figure 4, the main dashboard provides a general overview of the rural ambulance station. At the top, the mosaic-inspired visualization presents long-term trends in staffing composition. Beneath this, the highlighted table allows users to identify EMTs who did not meet the minimum shift requirement in a selected year.

Interactive drop-down menus enable users to select a specific EMT and year. Once selected, users can confirm their choices and navigate directly to the detail page for deeper insights into the individual's activity.

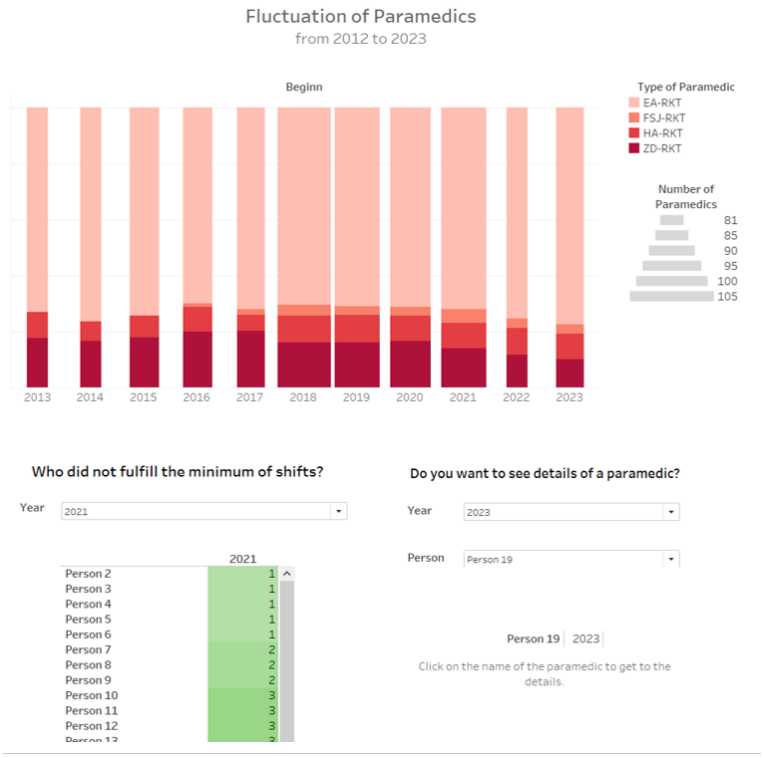

Figure 4: Main dashboard page offering overview of personnel trends and critical cases

Detail Page The detail page (Figure 5) focuses on a single EMT. The slope graph illustrates the EMT's monthly activity and station distribution. Below it, the lollipop chart offers insight into the balance of RTW vs. KTW shifts. This contextual understanding is further enhanced by a list of the five colleagues the EMT has worked with most frequently.

Together, these visualizations help domain experts evaluate behavioral patterns and potential causes of disengagement or reduced shift participation.

4.7. Interview Round 2

The final interviews were conducted to evaluate the effectiveness and utility of the dashboard. Feedback was highly positive. Domain experts found the visualization to be intuitive, informative, and directly applicable to their operational needs. The managing director of the rural ambulance station emphasized that this dashboard would be helpful for managing EMT retention more proactively.

There was feedback suggesting that future iterations should distinguish more clearly between ambulance services and health and social services (GSD), which would require separate data collection. This was considered a worthwhile direction for future development.

Experts highlighted that the mosaic plot effectively communicated category relationships and confirmed known trends, such as the decline in Zivildiener (civil servants) over the years. The table listing EMTs who failed to meet their shift minimum was seen as particularly useful for administrative planning.

Both interviewees affirmed that the detail page was well-designed for conducting individual assessments and follow-up conversations with EMTs. It provides clear insights into behavioral patterns that could indicate disengagement or dissatisfaction, supporting more targeted retention efforts.

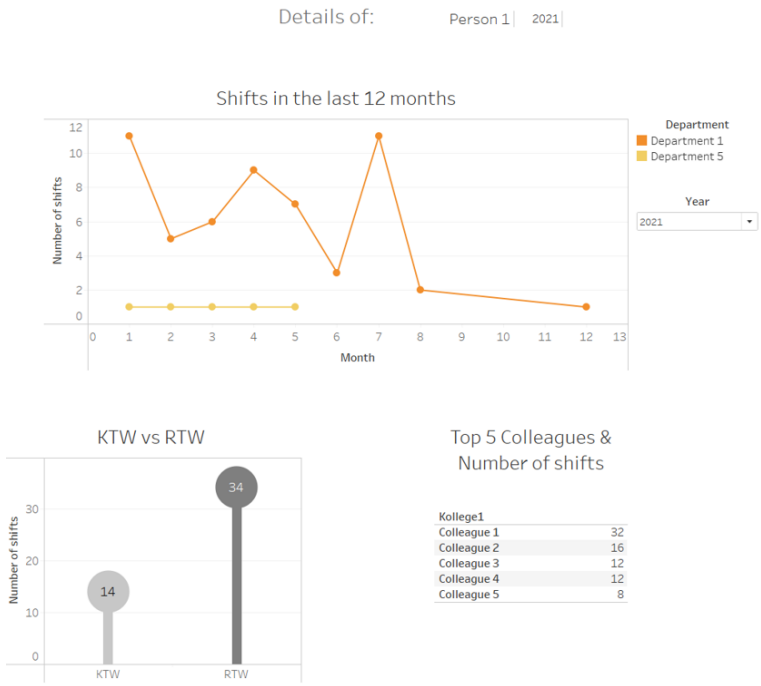

Figure 5: Detail dashboard page for analyzing individual EMT behavior

5. Conclusion

The findings are organized into three main parts. The first part discusses the related work and compares it with the visualizations created in this study. The second part addresses the utility of the developed visualizations based on the feedback from domain experts. Finally, the third part outlines potential future work, including improvements and further developments that could enhance the effectiveness of the visualizations.

Differences to Related Work One of the related works is a visualization done by Du et al. [12] called EventAction: Visual Analytics for Temporal Event Sequence Recommendation. This visualization shows event sequences in a timeline, which can be seen as related work to this paper. The difference in this paper is that to visualize the fluctuation of different EMT types, a mosaic plot similar visualization has been created. A similarity is that visualizations that help achieve the users' goals have been created in both visualizations. However, the visualizations to achieve these goals are different because the users of these visualizations have different goals. Further related work is also from the Human-Computer Interaction Lab of the University of Maryland [13]. One is called Timesearcher: Visual Exploration of Time-Series Data and the other is called Eventflow: Exploring point and interval event patterns [14]. These are mentioned because the width of the boxes determines an amount like the mosaic plot-like visualization in this paper. Furthermore, the TimeSearcher [15] includes a slope graph, like the detail page of the visualization in this paper. Both slope graphs have a one-year time span and are divided into months.

Utility The final visualization can be used in the daily work life of the domain experts according to their statements in the second interview. As this visualisation is problem-driven, its result is good and helps the domain experts with their real-life problem: the fluctuation of EMTs in their rural ambulance station. During the first interview, the domain experts voiced the necessity of such visualization, and according to the second interview, their expectations were fulfilled and, in the case of the district department commander, even exceeded their expectations according to their statement. Possible future improvements like separating the EMTs from the employees of the GSD even more than already done

need more data but are in general possible. According to the domain experts, the fluctuation can be better evaluated with the visualization, and they were also able to confirm expectations with the result. One of these expectations was that the relation of Zivildiener to the other EMT types became less during the last few years. Furthermore, the domain experts stated that they also had a new realization: the importance of the volunteers at their rural ambulance station.

Future Work One further question is the more precise separation of the EMTs from the GSD employees. GSD is short for "Gesundheits und Sozialdienste" and stands for other areas in ambulance organizations, for example blood donations. To create such separation, data on this is needed. This would allow the domain experts to evaluate the fluctuation better because the GSD employees have different requirements regarding the minimum of shifts than the EMTs. Also, a different structure on the detail page would be needed for these employees to ensure the best possible evaluation. A new evaluation of suitable visualization types is needed in this case. Also, if the necessary data is created, the typography of EMTs could be visualized. This could help domain experts to evaluate better formation options, like whom to allow a formation as a EMT with special allowances. According to domain experts, this can help to prevent EMTs from changing to other departments. While one of the requirements of this visualization was to help domain experts stop EMTs from quitting, a pattern recognition compared with a visualization of why people become EMTs to better place advertisements, for example, could also help manage the fluctuation better. With this solution, combined with the visualization in this paper, the fluctuation of EMTs could be better managed by the domain experts in becoming a EMT and quitting this occupation.

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