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Disaster Nephrology in Action: A Tech-Augmented Response to Cyclone Alfred

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Abstract

Cyclone Alfred disrupted dialysis services across South-East Queensland. Digital tools, including real-time surveys and AI-assisted analysis, were used to evaluate impact and guide immediate improvements. This low-cost, tech-enabled response demonstrated how agile methods can support disaster resilience and inform planning for vulnerable patient groups during extreme weather events.

Introduction

Severe weather events have a considerable impact on health care services, causing profound disruption of operations. Patients who rely on regular contact with health care, especially those with kidney failure, are vulnerable during such events.[1–3]

Tropical Cyclone Alfred, which struck South-East Queensland in March 2025, presented an opportunity to leverage new technologies to undertake rapid evaluation during the cyclone itself. A real-time mixed-methods audit was deployed using low-cost, readily available digital tools to rapidly record data and close the audit loop within days.

Methods

A mixed-methods audit in the fortnight following Cyclone Alfred (3-16 March 2025) was conducted. Patient and staff surveys were distributed electronically via Google Forms by circulating Quick Response (QR) codes that were presented directly to participants at dialysis centers. Paper copies were supplied as an alternative for patients with limited digital access. Surveys were distributed to all 203 center-based hemodialysis patients on maintenance dialysis and 110 nursing staff across Metro North Kidney Health Service. Responses were collected over a two-week period (3-16 March 2025).

AI-Assisted Thematic Analysis

Free-text responses were extracted and coded thematically using Generative Pretrained Transformer 4 (GPT-4), a large language model (LLM) developed by OpenAI (OpenAI, San Francisco, California). Prompts were designed to elicit inductive themes from de-identified narrative responses, and representative quotes were identified. Thematic categories were generated, reviewed, and iteratively refined to ensure interpretability. Outputs were reviewed independently by two investigators to ensure concordance. Key Prompts included:

- "Review the following de-identified patient feedback and generate inductive themes with short descriptive labels."
- "Summarize key themes from these responses, providing representative quotations for each."

GPT-4 outputs were reviewed independently by two investigators (AS, EOS) for accuracy, completeness, and interpretive validity.

Missed dialysis sessions were mapped by residence. Statistical Area Level 2 (SA2) Region. SA2 is a medium-sized geographical area in Australia. They have a population between 3,000 and 25,000 people. Spatial clustering was assessed using Moran's index and visualized on a choropleth map overlaid with flood hazard zones and dialysis unit locations.

To assess changes in emergency presentations, admission data were extracted from February 2024 to March 2025. Mean and standard deviation were calculated across non-cyclone months, and a Z-score was used to quantify deviation in March 2025 admissions. Inpatient episodes were analyzed, and total dialysis patient inpatient hours during the two-week peri-cyclone period were recorded. Each admission was independently coded by two investigators as cyclone-related or not. Participation in the survey was voluntary, and implied consent was assumed upon survey

submission. Surveys were anonymous, and no identifying or clinical information was collected. Data were stored securely in password-protected cloud spreadsheets accessible only to the study team. Completion or non-completion of the survey had no impact on clinical care, service access, or future treatment. The project received an exemption from ethical review from Metro North HREC (HREC/2025/MNH/120580).

Results

A total of 180 dialysis patients responded to 203 surveys sent (88% response rate), and 28 of 110 staff (25%) completed the survey 62.1% of patients reported session disruption, primarily due to transport failure or unit closures. Among affected patients, 36.8% reported fluid overload symptoms and 13.2% presented to an Emergency Department (ED). ED admission among dialysis patients rose from 66 admissions in February 2025 to 79 in March 2025 (a 19.7% increase), but this remained consistent with seasonal variation (Z = 0.39) and matched the year-on-year Feb to March increase observed in 2024. Dialysis patients accounted for 2.29% of all emergency department admissions in February, rising slightly to 2.58% in March. ED presentations per 100 dialysis patients also increased from 25.5 to 30.5 but were not statistically significant. Of 52 inpatient admissions during the two-week window, 3 (7% of inpatient hours) were attributed directly to the cyclone, due to transport disruption and home dialysis power failure.

A choropleth map revealed regional clustering of missed dialysis sessions (Figure 1, Moran's I = 0.13, $P = 0.01$), highlighting geographic vulnerability. There was no statistically significant association between patient age, postcode, and likelihood of disruption.

Patient feedback reflected a high level of trust and satisfaction with dialysis staff, with many describing the support they received as "reassuring" and "excellent under pressure." However, several respondents identified opportunities to strengthen future responses around after-hours communication and ensuring the pace of communication reflected evolving events. Staff advocated for similar communication enhancements, including formalized short message service (SMS) alert systems and enhanced patient database management.

Discussion

Despite extensive session disruption during Cyclone Alfred, the small increase in emergency admissions suggests existing preparedness measures were partially effective. However, AI-based analysis conducted during the disruption was able to identify opportunities to improve. Formal communication pathways, transport coordination, and after-hours support.

The use of digital tools enabled a rapid, low-cost audit with minimal administrative overhead. Recent studies have demonstrated that LLMs like GPT-4 can produce clinically relevant insights with high concordance with expert human reviewers, supporting their use in time-sensitive quality improvement contexts.[4–6] In this setting, LLM-assisted thematic analysis provided accurate, reproducible coding within minutes, without the need for trained qualitative researchers. A preliminary report was circulated

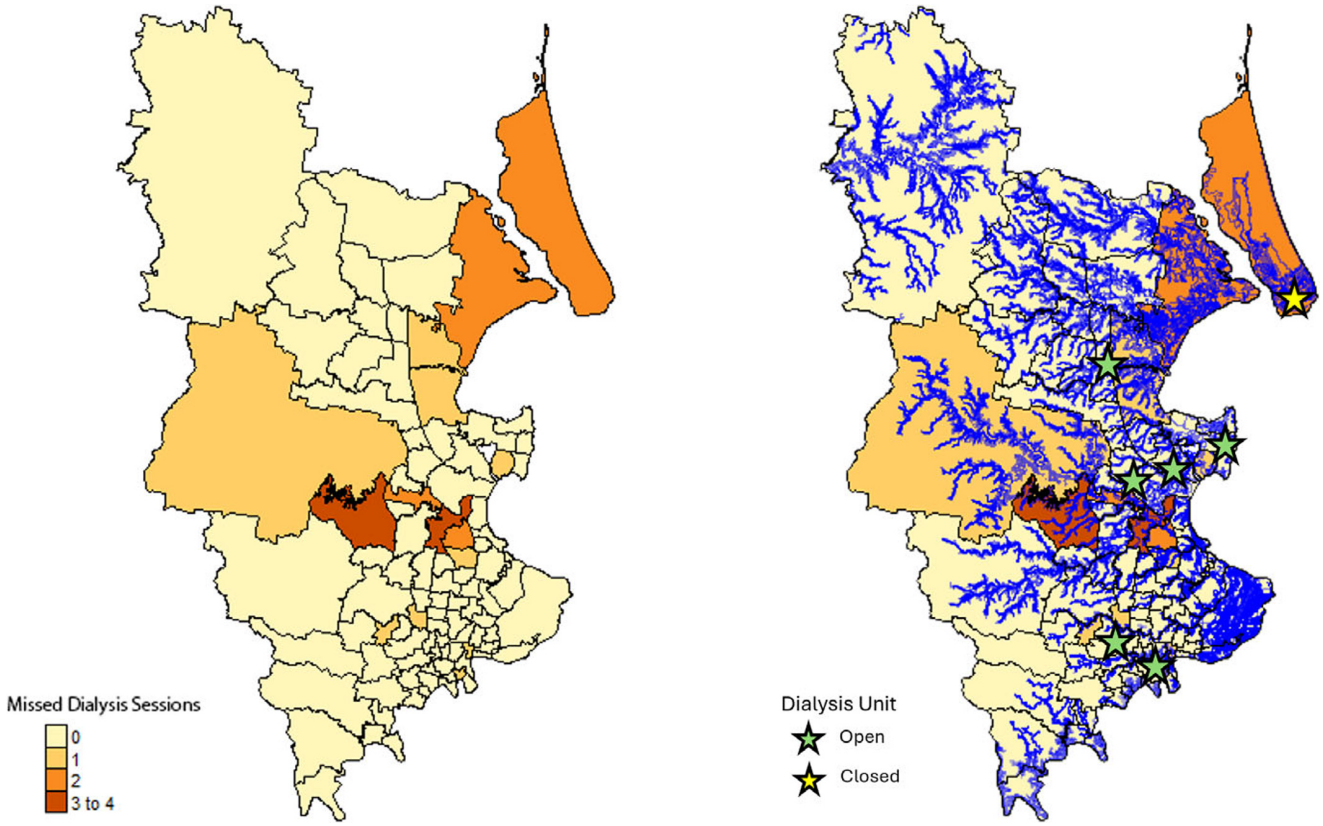


Figure 1. Geographic distribution of missed dialysis sessions during Cyclone Alfred and overlay of flood risk zones and dialysis unit status.
(Left): Choropleth map showing the number of missed dialysis sessions by Statistical Area Level 2 (SA2) region. Darker shades indicate higher frequency of missed treatments.
(Right): The same map overlaid with major hydrological features and dialysis unit status. Green stars represent dialysis units that remained operational; yellow stars indicate units that were temporarily closed.

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within five days of the cyclone. This speed of audit cycle would allow corrective actions to be undertaken during ongoing disaster operations.

As a single-center observational study without a comparator cohort, there is the risk of response bias or under-reporting. The analysis was not powered for causal inference, and geospatial resolution was limited to the SA2 level. The high response rate among patients mitigates, but does not eliminate, potential response bias. Participants who experienced greater disruption or who were more engaged with the service may have been more likely to respond, introducing selection bias. The response rate among staff was low (25%), introducing a potential source of non-response bias. Staff who experienced greater operational disruption or were more engaged with emergency planning may have been more likely to participate, which could overrepresent certain viewpoints.

These findings highlight the feasibility and utility of technology-augmented quality improvement, combining digital surveys, geospatial analytics, and AI-assisted analysis to inform preparedness strategies and response after the disaster.

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Author contribution. Eoin D O'Sullivan and Robert J Ellis conceived and supervised the study. Archee Singh and Nicholas Ehlers led data collection, analysis, and visualization, with contributions from Shaun Chandler and Sharad Ratanjee. All authors contributed to interpretation of results, manuscript drafting, and critical revision, and approved the final version.

Competing interests. None.

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