Dynamic health status monitoring using aged care quality indicators for better care: An innovative approach using mixture hidden Markov models

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Abstract: The National Aged Care Mandatory Quality Indicator (QI) Program (Australian Institute of Health and Welfare, 2023) has been mandated for all approved residential aged care services since 1 July 2019. The program has been designed with the objective of offering both providers and consumers with data to support the monitoring of quality and safety at individual facilities and across the sector. The program encompasses quality indicators for medication management, falls, and injuries. The program currently collects data on a quarterly basis at the aggregated facility level rather than at the resident level. While this approach enables identification of static care quality at the facility level, it does not capture resident-level dynamics in health status, which could contribute to better identifying individuals at risk and contribute to the delivery of more effective care. To address this gap, this study conducted a resident-level analysis of four quality indicators (polypharmacy, antipsychotic medication use, falls, and all-cause incident related hospitalisation) for permanent residents on a monthly basis during the first two years following admission.

We utilised Mixture Hidden Markov Models (MHMM), as proposed by Helske and Helske (2019), to identify different clusters of residents based on multi-channel trajectories. Covariates such as age, gender, dementia, mild cognitive impairment, and any circulatory condition, were incorporated to model the prior cluster probabilities and explain the cluster membership. A total of 31 different models were trained by varying the number of clusters from two to four, each with two to four hidden states. To find the optimal solution, each model was simulated 100 times. The Bayesian Information Criteria (BIC) was used to evaluate the goodness of fit, and the best model was selected based on the elbow point, interpretability, and simplicity. Specifically, the BIC values rapidly decreased with an increase in the degrees of freedom until reaching an elbow point, beyond which the rate of decrease slowed. The model corresponding to the elbow point was deemed the best-fit model.

The study found that two clusters demonstrated a stable pattern in terms of the risk of falling and all-cause hospitalisation, while the other two clusters exhibited high and medium risks in falls and all-cause incident related hospitalisation. The two stable clusters were characterized by residents without polypharmacy and antipsychotic medication use, while the high risk of falls and all-cause incident related hospitalisation was observed among patients using antipsychotic medications and polypharmacy, followed by the medium risk of falls and all-cause incident related hospitalisation seen among residents with polypharmacy. Moreover, 47% of the residents were in the medium risk cluster followed by 31% in stable clusters and the remaining 22% in high-risk cluster.

The study also employed an interactive model interpreting framework to visualize the model output, including emission probabilities and transition probabilities within and between states, respectively. Identifying resident clusters and their state membership, as well as understanding the transition probabilities between states within a cluster, can aid providers in personalizing care for improved health outcomes. As such this approach can potentially reduce the incidence of falls and hospitalisations at the facility level while enhancing the overall quality of care.

REFERENCES

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