FLoSC
Forecasting Length of Stay and Cost

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In England, long-term care (LTC) consists mostly of social service programs run by local councils, and residential care (RC) and nursing care (NC) provided in institutional care homes. In general, RC consists of board and personal care for those who are frail but still able to manage their activities of daily living; while NC is for elderly people who are medically stable but have a greater degree of physical and mental disability and require input from a NHS (National Health Service) registered nurse. We use the term Institutional LTC to collectively refer to RC and NC.

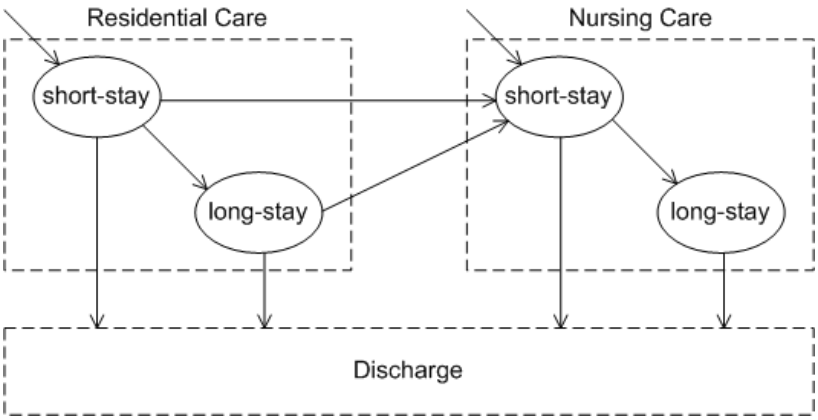
Publicly funded residents in institutional LTC constitute a large proportion of admissions to LTC in England, and hence represent a major consumption of a local council's LTC resources. National longitudinal surveys in England have shown that most of the publicly funded residents who are admitted to institutional LTC are there on a permanent basis. For these residents, discharge from LTC is predominantly by death; very rarely residents are discharged to the community (i.e. well enough to be maintained in their own homes); and discharge to a hospital usually means terminal care. National surveys also found that about 20% of the residents admitted to RC would be transferred to NC sometime during their stay; however, movements from NC to RC rarely occur. Furthermore, due to their obligations to use public funds for the purchase of RC and NC, most local councils have organised means of determining suitable care placements for these residents. Therefore, these admissions usually reflect the physical conditions and care needs of the residents.

The cost forecasting framework
The cost of institutional LTC is mainly influenced by the type of care a resident is receiving and its corresponding length of stay (e.g. patterns on survival and movements in the system), and the future development of cost in delivering the care due to the fact that admissions are often on a long term basis. Therefore, the main components underlying the cost forecast by FLoSC are:

- a stochastic model capturing the survival and movement patterns of publicly funded residents in institutional LTC;
- a cost model describing the cost development in the future.

Model for survival and movement patterns
For administrative purposes, local councils routinely collect data about residents under their care such as date of admission, place of admission, date and place of transfer, and date of discharge if applicable. Simple analysis of these data, such as calculating the average LOS in care, are often performed in attempts to extract useful information to aid planning. However, due to the high degree of skewness that is common in this type of LOS data, the use of average LOS, a single number, to describe the overall LOS pattern gives incomplete and often misleading information. A more sophisticated approach to the analysis of this type of administrative data is required.

Research in the U.K. has shown that the mortality rate for publicly funded residents in NC is particularly high in the first few months, and then gradually levels out. This observation supports the notion of different phases in the stay of residents in care homes. Therefore, we propose to use a combination of conceptural states (i.e. a short-stay state and a long-stay state) to capture a resident's stay in a type of care (see the following diagram). For instance, a resident admitted to RC might stay for a short period of time, then is either discharged (predominantly by death) or transferred to NC; or settle down and become a long stay resident in RC. Eventually the resident is either discharged or transferred to NC for further stay. This relatively simple structure of the model is conceptually intuitive to many practitioners working in the LTC system.



Based on this concept, we formally construct a continuous time Markov model of the flow of elderly people within and between residential and nursing care. The phases in each type of care and the discharge state form the system states. The rare movements such as discharge home and transfer from NC to RC are not considered in this model. Due to the Markov property, LOS in a state follows exponential distribution.

However, it is worth stressing that the phases (i.e. short-stay state and long-stay state) are conceptural and are not observable precisely in practice. We can only observe which type of care a person is in. For example, at any time, we observe that a person is in RC but we do not know whether she or he is in a short-stay state or long-stay state. Technically, this is known as an aggregated Markov process, i.e. a Markov process in which underlying system states are aggregated into a number of observable classes.

The parameters of the Markov model (i.e. the transition rates) are estimated from observational data by the method of maximum likelihood. We developed a two stage procedure for fitting the Markov model to observational data. Briefly, the first stage determines the structure of the model (the number of states in each class) by fitting models with increasing number of phases (or states) to observed LOS data in each class separately. The number of states is chosen based on the Bayesian information criterion (BIC), which is a measure representing a compromise between model complexity and goodness-of-fit. In other words, the number of state in a type of care is adaptively estimated from data. It is not necessary that a combination of short-stay and long-stay state is always needed. Once the structure of the Markov model is specified, we proceed to fit the Markov model to the overall LOS data by numerically maximising the joint likelihood function.

Model for cost development
In practice, the (gross) unit costs of LTC (from the local authorities' point of view) are usually negotiated between the local authority (the purchaser) and the home owners (the providers) at the beginning of a financial year (1 April in the UK) and remain constant for the rest of the financial year. Seldom do unit costs increase during the year. Studies have pointed out that the variability in the cost of LTC is mainly attributed to the type of care a resident is in rather than the resident's individual characteristics, and the annual increase in unit cost for RC and NC is small and only slightly above inflation. Therefore, for both RC and NC, we describe the development of average weekly cost of care as constant with annual increments on 1 April each year.

Putting it all together
FLoSC is a software implementation of this cost forecasting framework. With FLoSC, a local authority can easily use their local data to derive a customised model for the patterns of survival and movements of residents in their LTC system, and combine it with cost information describing the development of weekly cost of care to produce forecasts for the cost of their known commitments.

Reference
The following is a list of published academic papers describing the methodology underlying FLoSC.

Xie, H., Chaussalet, T.J., Toffa, S. and Crowther, P. (2006) A software tool to aid budget planning for long-term care at local authority level. *International Journal of Medical Informatics*, 75:664-670.

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