A Software Tool to Aid Budget Planning for Long-Term Care at Local Authority Level

Haifeng XIE, Thierry CHAUSSALET, Sam TOFFA and Peter CROWTHER

Health and Social Care Modelling Group
Centre for Health Informatics
University of Westminster
London, UK
Brief Background

- **Long-term care (LTC)**
  - Health, personal and social care provide to older people

- **The system of LTC in the UK**
  - Social service programs, residential care (RC), nursing care (NC)
  - Institutional LTC (ILTC) refers to RC and NC collectively

- **The role of local authorities in the system of ILTC**
  - 1990 NHS and Community Care Act
    - Placement and finance all publicly funded residents
  - Care Standard Act 2000
    - Provide care that conforms to national standards
  - Delayed Discharges Act 2003
    - Fined if fail to provide vacancies in ILTC for hospital discharges

- **Main concerns for local authorities**
  - How long they stay
  - How much they cost
Publicly Funded Residents

We focus on publicly funded residents in ILTC

- **Main characteristics**
  - Admitted on permanent basis
  - Admission reflects their physical conditions and needs
  - Discharge predominately by death, rarely discharge to community
  - Discharge to hospital usually means terminal care
  - About 20% RC residents transfer to NC
  - Movement from NC to RC is rare
  - Mortality rate is high in the first few months of admission to NC, and gradually levels out
Known Commitments

- Known commitments (from local authority's point of view)
  - The group of publicly funded residents currently present in ILTC
- Cost from known commitments
  - The costs of ILTC incurred by known commitments
  - Resources committed due to past admission decisions
  - Costs that local authorities cannot escape
  - Not sensitive to future changes in admission policy and demographic structure
- Why cost from known commitments?
  - Provide a fair idea about their ability to admit new residents
  - A step towards forecasting total costs in ILTC
Forecast Cost from Known Commitments

- To forecast the total cost of maintaining a group of residents in RC and NC for a period of time.

- Need to take into account
  - Survival patterns in RC and NC
  - Possibility of RC to NC transfer
  - Developments in cost of care
We seek to forecast the total cost $TC(t)$ of maintaining $M_R$ and $M_N$ number of publicly funded residents in RC and NC, respectively, at time $c$ for a further time period $t$.

Cost incurred by a resident during $[c, c+t]$ is $K(X, Y) = K_R(X) + K_N(Y | X)$, where $X$ and $Y$ represent the number of days a resident spent in RC and NC during $[c, c+t]$.

$TC(t) = \sum_{i=1}^{M_R} K(X_i, Y_i) + \sum_{j=1}^{M_N} K(0, Y_j)$

We are interested in $E[TC(t)]$ and $\text{Var}[TC(t)]$. 
Outline for the Rest of the Talk

- Survival model
  - Movement of residents within and between RC and NC
- Application of the cost framework to an English local authority
- Software implementation of the cost framework
- Conclusion and future work
Models movement of residents within and between RC and NC

- Much research work has indicated great heterogeneity in survival
  - Model residents' stay as a two-phase process: short-stay and long-stay
- Continuous-time Markov model
- Aggregated Markov process
- Distributions of length of stay (LOS) in RC and NC are Coxian
Survival Model – Fitting Procedure

The fitting procedure

- First stage – determining particular model structure from data
  - Fit Coxian distributions with increasing number of phases to LOS data for each type of care by MLE
  - Use AIC or BIC to select the “best” number of phases

- Second stage – fitting the overall model
  - Maximisation of the likelihood function by quasi-Newton method
  - Sensible starting point obtained from the fitted results at the first stage

- Need to take into account left-truncated and right-censored observations
Survival Model – Application to Merton

Data

- Four years cohort data (publicly funded residents admitted to RC and NC between 1 April 1997 and 1 April 2001)
- Provided by the London Borough of Merton
- Left-truncated and right-censored observations
Upon leaving RC, 18% of residents will transfer to NC

About 64% of those admitted to NC will become long-stay residents

In NC, mortality in short-stay state is about 5 times that in long-stay state

Once residents in NC survive through the short-stay state, their survival pattern will be similar to those in RC
Survival Model – Application to Merton

[Graphs showing survival functions for length of stay in ICU and non-ICU settings]
Cost Framework – Application to Merton

- **Known commitment**
  - Publicly funded residents in ILTC on 1 April 2001
    - 252 in RC
    - 187 in NC

- **Survival distributions in RC and NC** are from the fitted results of the Markov model

- **Development of unit cost of care** described by a step function
  - Variability in cost is mainly attributed to type of care a resident is in rather than their individual characteristics
  - Unit costs are usually negotiated at the beginning of a financial year and remain constant for the rest of the year
  - Annual increase in unit cost is small and only slightly above inflation
We forecast the cost of known commitments of Merton for a further 7 years from 1 April 2001

Projected annual cost by type of care
Software Implementation

- **Aim**
  - To implement the cost framework
  - To develop a decision aid for local authority budget planners

- **Main features**
  - User friendly
    - In familiar Microsoft™ Windows™ environment
    - Wizards style GUI
    - Choice by point-and-click
  - Link to existing information system (for latest data)
  - Flexibility and extendibility
  - Reporting facility
Components of Implementation

- Three main components
  - GUI, back-end computation engine, reporting unit
  - Exchange data via XML files

![Diagram of components](image)
Residents who were present between the following dates will be included in the data set:

From 10 May 2000
To 27 May 2006
Screen Shots (2)
Report: cost analysis

This analysis was carried out on 2005-05-19 at 15:13:59.

- General information
  - Fitted LOS model
  - Data for forecasting
  - Data cleaning and data processing

- Summary information on all residents currently in system
  - Summary statistics on length of stay

- Forecasting scenario(s)
  - Projected unit cost of care under the scenario(s)
  - Projected total cost of current commitment under the scenario(s)
    - Break-down of the projected total cost by cohort
    - Plot of break-down of projected total cost by cohort under Scenario 1
    - Plot of break-down of projected total cost by cohort under Scenario 2
    - Break-down of the projected total cost by type of care
    - Plot of break-down of projected total cost by type of care under Scenario 1
    - Plot of break-down of projected total cost by type of care under Scenario 2

- Comparison between scenarios
  - Difference in projected total cost of current commitment
    - Plot of difference in projected total cost of current commitment
  - Break-down of the difference in projected total cost by cohort
    - Plot of break-down of difference in projected total cost by cohort
  - Break-down of the difference in projected total cost by type of care
    - Plot of break-down of difference in projected total cost by type of care
Summary of the Implementation

- Simple data requirement
  - Day-to-day administrative data
- Modular approach
  - Different software tool for different component
- Exchange data and information via XML files
- Flexible reporting facilities
  - HTML – on screen viewing and ready for web publishing
  - PDF – printing and documentation
  - Brief or detailed report
- Use of quality free software – e.g., R, \texttt{\LaTeX}, etc
  - Cost beneficial to public sectors
Conclusion and Future Works

Conclusion

- Provide data-derived information to aid budget planning for LTC
- Useful software implementation
  - Hide the complexity of underlying methods
  - Bring advanced modelling techniques to end users
- Very good feedback from end users
  - Easy to use and produce sensible results
  - Most useful – end of financial year forecast
- Fruitful collaboration between academic and industry

Future works

- More software testing/improvement
- Validation of the cost framework
- Web interface?