How to predict high dependency cot demand in upcoming days

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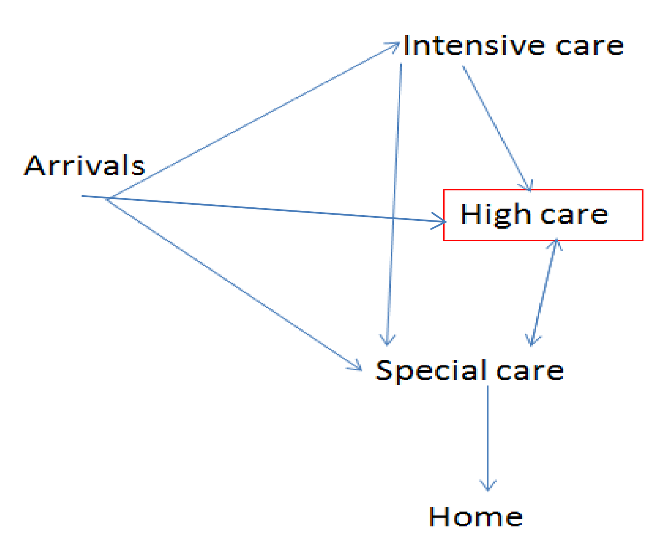
1. Problem

High Dependency Care in the English local neonatal unit lies at a busy node in the system. High care encompasses non-invasive respiratory support (CPAP), close observation for drug withdrawal symptoms (NAS) and intravenous feeding (TPN) for gut conditions like necrotising enterocolitis (NEC). Those repatriated from intensive care centres must be accepted within 24 hours. One trained neonatal nurse may care for two high dependency babies. We wish to predict demand for high dependency care. We have knowledge of range of cot occupancy, length of stay (LOS), age and diagnosis. Having warning of peaks in demand would be quite useful for timing decisions on elective deliveries as well as repatriations from other hospitals.

2. System



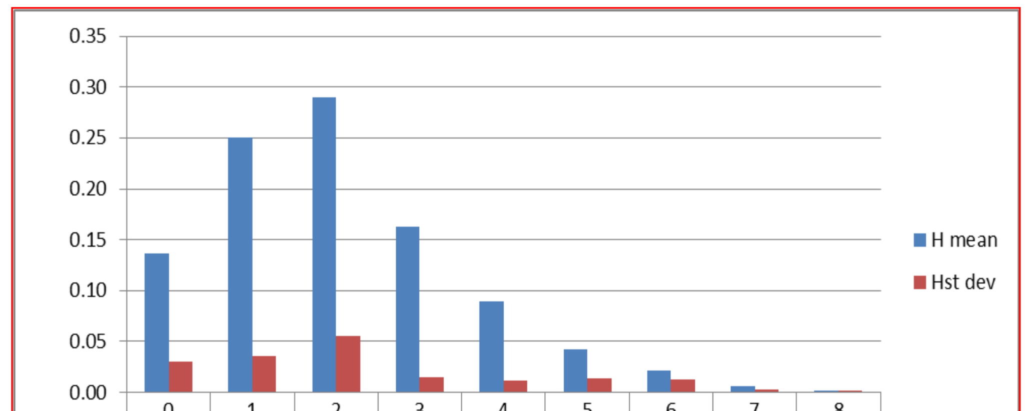
$$H_t = H_o + H_a + IH + SH - H_d$$

Where H_t and H_o are High Dependency census at time t and time zero; H_a is arrivals direct , IH and SH those arrivals there via intensive and special care respectively and H_d is those leaving high dependency care, all within the time-spell t over which a forecast is required.

Those patients staying are admissions less discharges. A run of day(s) at one care level we term an episode. Data is drawn from the Standardised Electronic Neonatal Database (SEND) database 2009-11. 85 patients arrived direct to high care giving a mean daily arrival rate of 0.078. Data is shown next, then explained in the commentary.

3. NHS Colchester Data: Occupancy and Length of Stay

Figure 2: Probability by number of High care cots occupied



	0	1	2	3	4	5	6	7	8
H mean	0.14	0.25	0.29	0.16	0.09	0.04	0.02	0.01	0.00
Hst dev	0.03	0.04	0.06	0.02	0.01	0.01	0.01	0.00	0.00

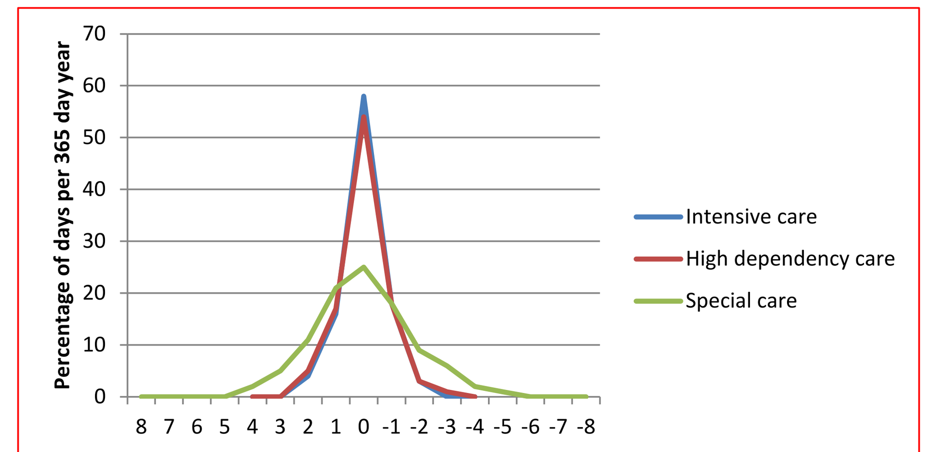


Figure 3: Daily change in cot occupancy

Figure 4: Length of Stay by Intensive, High and Special care episode

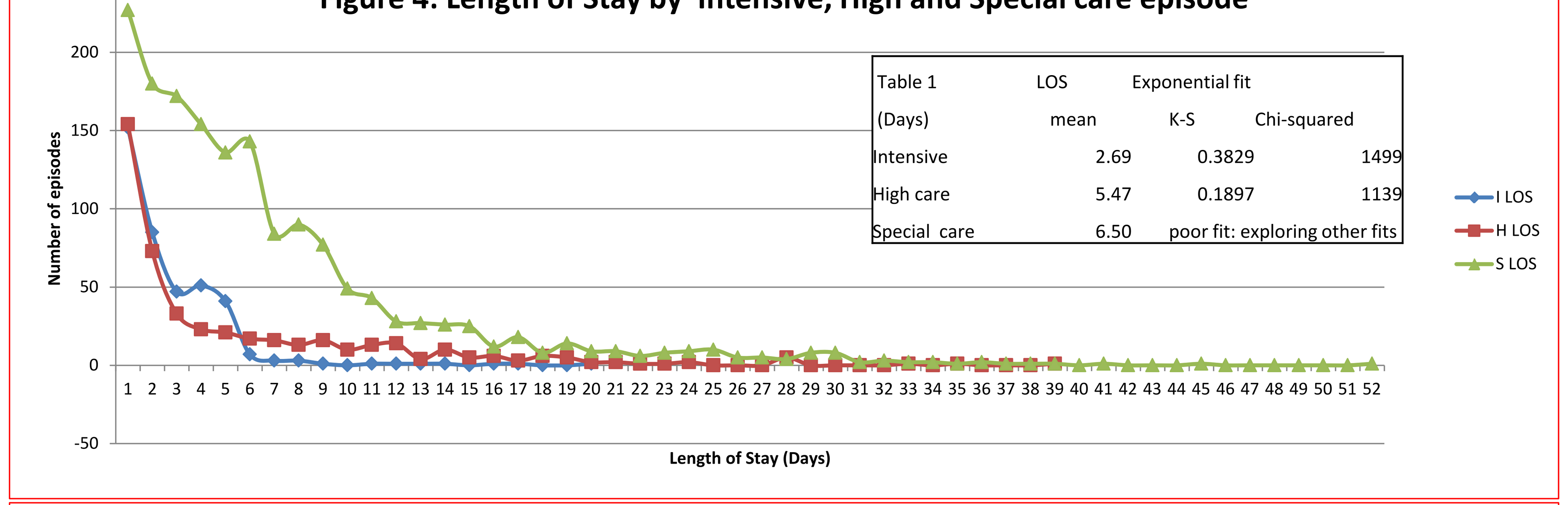


Table 1	LOS	Exponential fit	
(Days)	mean	K-S	Chi-squared
Intensive	2.69	0.3829	1499
High care	5.47	0.1897	1139
Special care	6.50	poor fit: exploring other fits	

Figure 5: Length of High Dependency care episode by condition

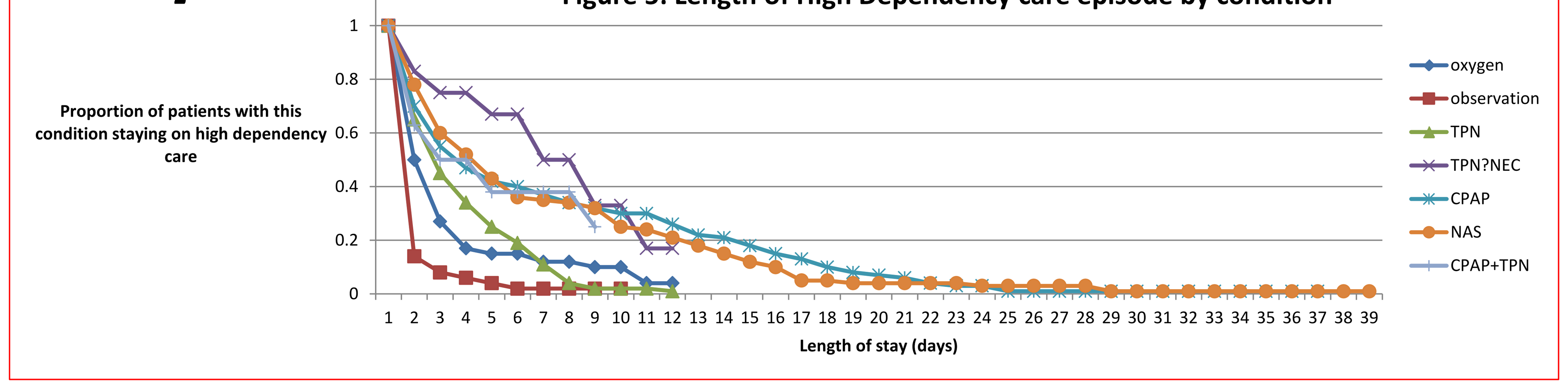


Figure 6: H_d – long staying groups

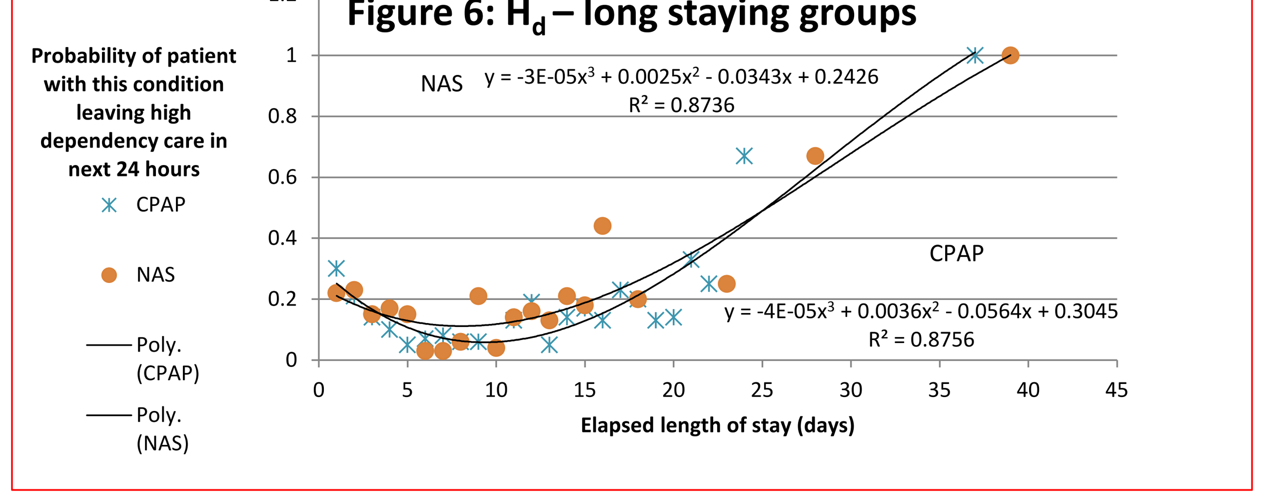


Figure 9: Comparison of Actual versus forecast for 48 hours of census I=1,H=4,S=?

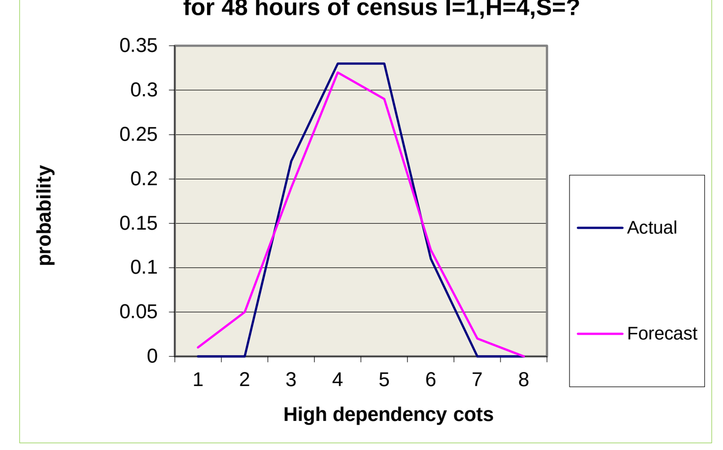


Figure 7: IH transition

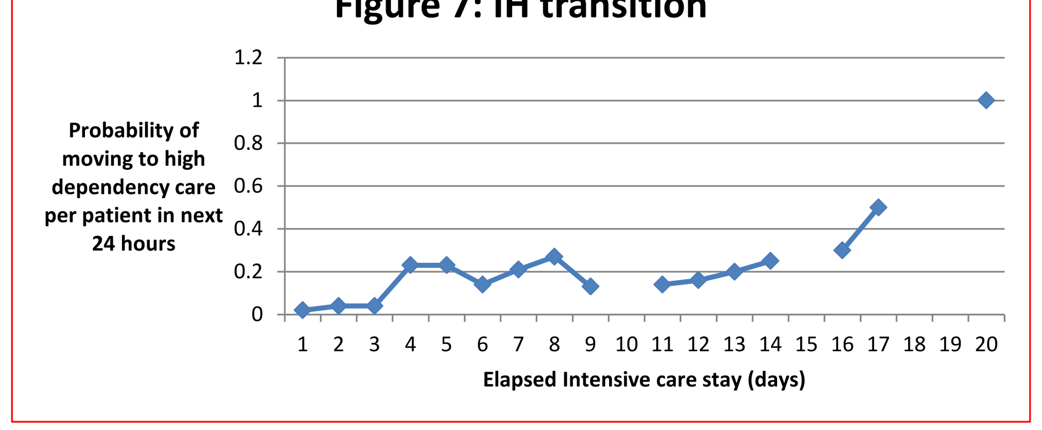
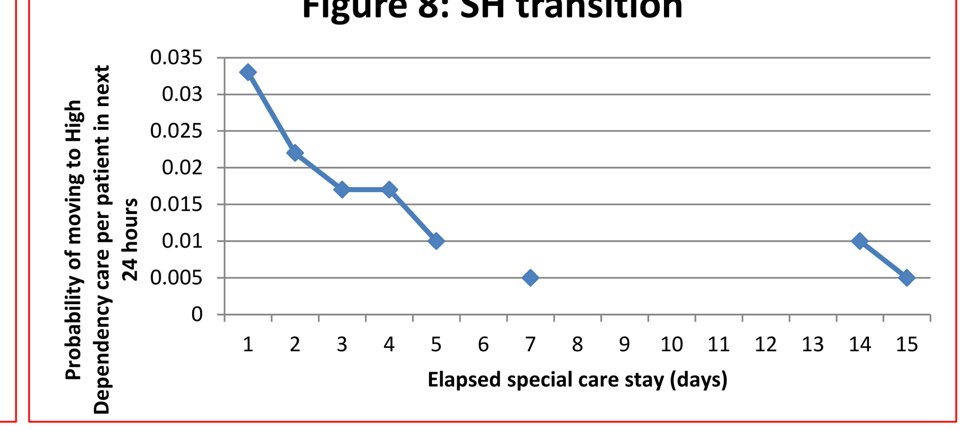


Figure 8: SH transition



4. Commentary

High dependency cot occupancy, both its distribution and error are shown in Figure (Fig) 2. Idle time is 14%, whilst cot shortage (>4 required) is 9% of the time. The daily change in cot occupancy at each care level appears to be normally distributed (Fig 3). 90% of daily changes in high care are by up to one cot. The goodness of fit of length of stay for the exponential distribution is given (Table 1). Curves for high and special care have long tails (Fig 4). Knowing the high dependency treatment or diagnosis helps to group and so further refine the specific length of stay forecast (Fig 5). Stays for CPAP for chronic lung disease and NAS represent the longest (Fig 6). Knowing the day of age of patients helps with an estimate of whether and when a move to high care occurs. Longer stays at intensive care (whose treatment contributes to lung disease) guarantee this (Fig 7) whilst longer stays at special care (presumably indicating stability) gravitate against it (Fig 8). Unfortunately space precludes our presenting analysis of corrected gestational age.

Now supposing today's cot count is 1 intensive care and 4 high dependency patients, ie. full, what is the chance of cot shortage in 2 day's time? This prediction is made using the equation and the binomial theorem (2009 data) and tested (2010 data) in Fig 9.

5. Claim

Knowing census at each care level, age of patient and reason for which the care is given permit refinement of the prediction of demand for high dependency care. This model may be simulated.

6. Discussion

No doubt shortcomings occur to you. Just one unit has been studied and where practice and policy change, predicting the future behaviour of the system becomes less reliable. Nevertheless as stringencies affect our healthcare economies, harnessing existing data efficiently to predict activity, matching resources to demand, reducing hospital length of stay and improving family experience such that the newborn is treated promptly and discharged home safely yet sooner are likely to become increasingly important.

We would like to acknowledge the data-cleaning of the ward clerk Ms Sexton and the words of Professors Millard, Gallivan (UK) and Harrison (US).