V.A. HOSPITAL QUALITY MONITORS: 1988-1997

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This report discusses reanalysis of VA hospital quality monitor data sets as described in West and Aguilar (1997) *"Studies of Quality Monitor Time Series: The V.A. Hospital System.* In Fall 1998 the data set was updated from the original eight years of to ten years, 1988-1997 inclusive. The extended data has been studied using the models of the above report, and some basic summaries of the analysis are detailed here.

Contents

1 Introduction

The study of VA quality monitor time series in West and Aguilar (1997), summarised in Aguilar and West (1998), concerned annual quality measures over the years 1987-1995. We summarise our reanalysis with the inclusion of an additional two years of data, extending the time scale to include years 1996 and 1997. Full background and modelling details appear in the above references. We adopt the `MODEL-2` framework, in which care-area and hospital specific annual quality measures are related over the years through a time series model, while maintaining an hierarchical model for the hospital population within each year. The model also estimates changes in underlying quality levels that are system-wide, and regression effects of the DRG predictor variables.

The data on a single monitor collected in one year across hospitals $i = 1, \ldots, I$ are patient numbers of *non-returns to follow-up care within 30 days of release*. High outcomes represent "poor quality." The study here concerns the full ten years of data on Monitors 20 (general psychiatric discharge) and 21 (substance abuse psychiatric discharges) only. Data for all years is available on $I = 144$ hospitals (compared to 152 in the original study). The annual proportions of non-returns across these hospitals 144 appear in Figure 1. This crude summary indicates a general decreasing trend since 1991, with an apparently most marked decrease in 1997, consistent with generally increasing "quality" in these care areas.[1]

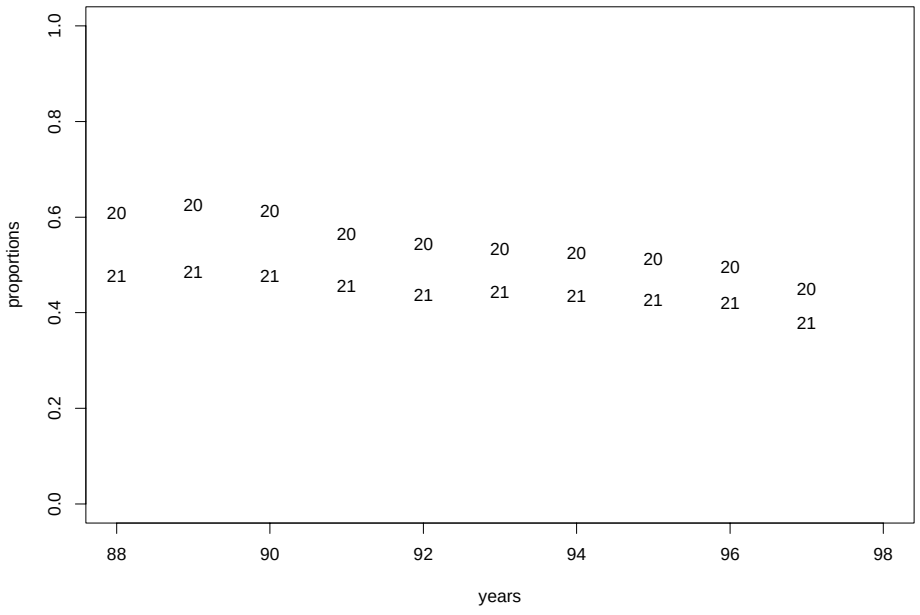

Figure 1: System-wide proportions of non-returns in monitor areas 20 and 21, by year.

[1] By contrast, there was an apparent decrease in quality identified in our earlier analysis of a third care area – monitor 22 – for 1995. We do not have additional years of data for monitor 22 so cannot explore whether or not that apparent change persisted into later years.

2 Summary of Model-2

Considering each monitor/care-area separately, the uni-monitor, random effects/time series model is as follows.

Write z_{it} for the number of non-returns in hospital $i = 1, \ldots, I$ and year $t = 1, \ldots, T = 10$, and write n_{it} for the corresponding total number of patients. Further, write x_{it} for the mean-corrected logit predictor $x_{it} = l_{it} - \bar{l}_t$ where $l_{it} = \log(d_{it}/(1 - d_{it}))$, d_{it} is the DRG predictor (as a proportion) in hospital i and year t, and $\bar{l}_t$ is the average of the l_{it} over hospitals i in year t.

Then, independently across hospitals i, the data are conditionally independent binomials,

$$(z_{it}|n_{it}, p_{it}) \sim Bin(z_{it}|n_{it}, p_{it})$$

with logistic regression on the DRG predictors and random effects,

$$\mu_{it} \equiv \log(p_{it}/(1 - p_{it})) = \beta_{0t} + \beta_{1t}x_{it} + \epsilon_{it} + \nu_{it} \tag{1}$$

with the following components:

- Sampling variability is modelled in the data-level binomial distributions;
- Unconstrained year-to-year variation is modelled in the VA system-wide or population levels of logit-probabilities, β_{0t};
- Unconstrained year-to-year variation is allowed through the regression coefficients on the DRG-based predictor, β_{1t};
- Structurally related hospital-specific random effects parameters ϵ_{it} represent hospital/year departures from the DRG-corrected population level of probability of response in the monitor care area;
- Residual, unexplained components ν_{it} measure residual variations in the outcomes not explained by the components above.

Additional model structure includes the forms of distributions for random effects and time series model, as follows:

- The β_{0t} and β_{1t} are unconstrained, treated simply as parameters to be estimated.
- Within each hospital, the ϵ_{it} are dependent over years t as modelled by

  $$\epsilon_{it} = \phi\epsilon_{i,t-1} + \omega_{it}$$

  where ϕ is a (positive) correlation coefficient between consecutive years, and $\omega_{it} \sim N(\omega_{it}|0, u^2)$ independently over hospitals i and years t. In each year marginally, the ϵ_{it} appear as a random sample of I draws from the implied marginal distribution $\epsilon_{it} \sim N(0, w^2)$ where $w^2 = u^2/(1 - \phi^2)$.
- The residuals are white noise, $\nu_{it} \sim N(\nu_{it}|0, v^2)$ independently over i, t.

Analysis produces samples from posterior distributions for all fixed model parameters and random effects, i.e., for

- ϕ, w, v,
- β_{0t}, β_{1t} for each $t = 1, \ldots, T$,
- ϵ_{it}, ν_{it} for each $i = 1, \ldots, I$ and $t = 1, \ldots, T$.

Posterior samples may be studied to explore inferences on these quantities, and summarised using standard graphical and numerical summaries. Many instances of this appear in West and Aguilar (1997) for the analysis of years 1-8 only. The next section briefly reviews a few such summaries from the analysis now extended over years 1-10.

3 Summaries of Analysis

Summaries of analysis of each of the two monitors separately appear in the figures in formats precisely as used in the earlier reports. The following comments summarise the key and relevant features of these graphs.

3.1 Hospital population parameters

Across years, inferences for the β_{0t} and β_{1t} are summarised via the posterior boxplots in Figure 2 for both monitor 20 and 21. The figure also displays posterior boxplots for the system parameters w, v, ϕ for each monitor. The graphs are entirely consistent with the earlier analysis of the first eight years of data. Our main comments relate to inferences on the β parameters.

There are meaningful differences in the β_0 parameters across the ten years in each of the two monitors. The main feature is a general decreasing trend in β_0 over the years corresponding to the generally increased quality levels as earlier remarked. The decreases in the system level parameter in 1997 is particularly marked, as detailed in inferences on the changes in levels, i.e., $\beta_{0t} - \beta_{0,t-1}$ over years t, in Figure 3. The probabilities that $\beta_{0t} < \beta_{0,t-1}$ are shown in the following table:

	1989	1990	1991	1992	1993	1994	1995	1996	1997
M20	0.1238	0.8526	0.9992	0.9068	0.6356	0.7374	0.8878	0.8608	0.9984
M21	0.2630	0.7546	0.9014	0.9098	0.2864	0.7522	0.7388	0.8902	0.9576

Inferences about the components of variance w and v, and on the "persistence" parameter ϕ, are essentially as earlier presented. The additional two years of data are quite consistent in these respects with the earlier eight years.

3.2 Random effects for two example hospitals

Summary inferences for the hospital/monitor specific combined random effects $\epsilon_{it} + \nu_{it}$ for two selected hospitals are given in terms of posterior boxplots for each year, for each of the two monitors. The selected hospitals are labeled #1 and #2, and the resulting displays are similar to those in the original analysis. These appear in in Figures 4 and 5 for both monitors

together. These exemplify the kinds of hospital specific inferences that can be made from this model framework. These summary inferences on individual $\epsilon_{it} + \nu_{it}$ quantities combine data across hospitals and across years, "borrowing strength" through the hierarchical model within each year for the hospitals as a population, and through the time series models across years within each hospital. The variations over time in each $\epsilon_{it} + \nu_{it}$ represent the quality level at hospital i that is formally corrected for changes in system-wide quality levels and for the hospital/year specific DRG levels. Additional examples of summary inferences for the combined random effects across the full set of hospitals within one chosen year – 1995 – appear in Figure 6 for Monitor 20 and Figure 7 for Monitor 21.

3.3 Additional comments

Additional investigations have included graphical assessments of model adequacy via standard Bayesian residual analysis, again mirroring similar studies in the original report. As in the original report, we are satisfied with the general model framework – none of our graphical exploration of aspects of model fit indicate any kind of meaningful departures from model assumptions. The scale of the model does, however, mean that there are many aspects of model fit left unexplored.

The kinds of summary inferences that may be drawn from these models are limited only by our imagination in designing queries for the software developed to implement them. To explore questions about specific issues – such as patterns of change over time in quality level parameters and random effects at specific hospitals – we simply need to produce a list of specific target issues to address. Then it is an easy matter to design queries to interrogate the model analysis and produce inferential summaries directly addressing those issues. Current software can be easily modified to do this. Example issues might include attempting to identify any "interesting" institutions whose patterns of change differ from the majority. Assessment of changes in rank status may help probe this issue, and inferences on ranks of hospitals – based on any selected random effect (time series, combined) or other index – are easily produced, again as was extensively illustrated in the original report in discussing issues of institutional rankings and comparisons. Follow-up discussions with VA personnel may lead to redevelopment of aspects of the software to permit easy and routine investigation of specific institutions at this level of detail.

4 References

Aguilar, O. and West, M. (1998) Analysis of hospital quality monitors using hierarchical time series models. In *Case Studies in Bayesian Statistics, Vol 4*, (eds: C. Gatsonis et al), New York: Springer-Verlag, pp287-302.

West, M. and Aguilar, O. (1997) Studies of Quality Monitor Time Series: The V.A. Hospital System. *Manuscript*, Management Science Group, U S Department of Veterans Affairs, and *ISDS Discussion Paper #97-22a*, Duke University.

Burgess, J.F., Christiansen, C.L., Michalak, S.E., and Morris, C.N. (1996) Risk adjustment and economic incentives in identifying extremes using hierarchical models: A profiling application using hospital monitors, *Manuscript*, Management Science Group, U S Department of Veterans Affairs, Bedford MA.

5 Graphical Summaries of Analysis

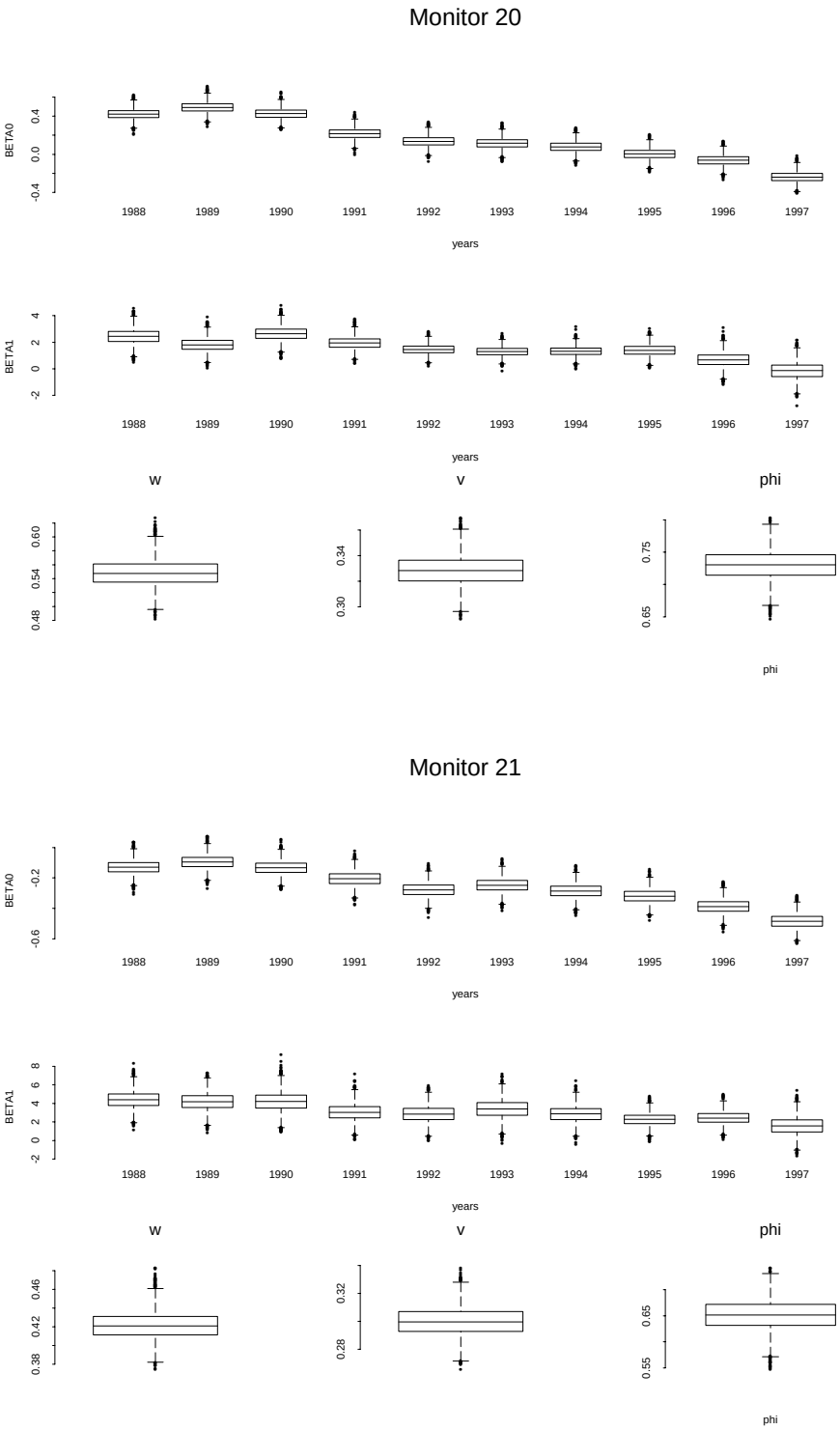

Figure 2: Posterior summaries for: system quality level β_{0t} and DRG regression coefficients β_{1t} by years $t = 1, \ldots, 10$; and system parameters w, v, ϕ. Upper frame: Monitor 20. Lower frame: Monitor 21.

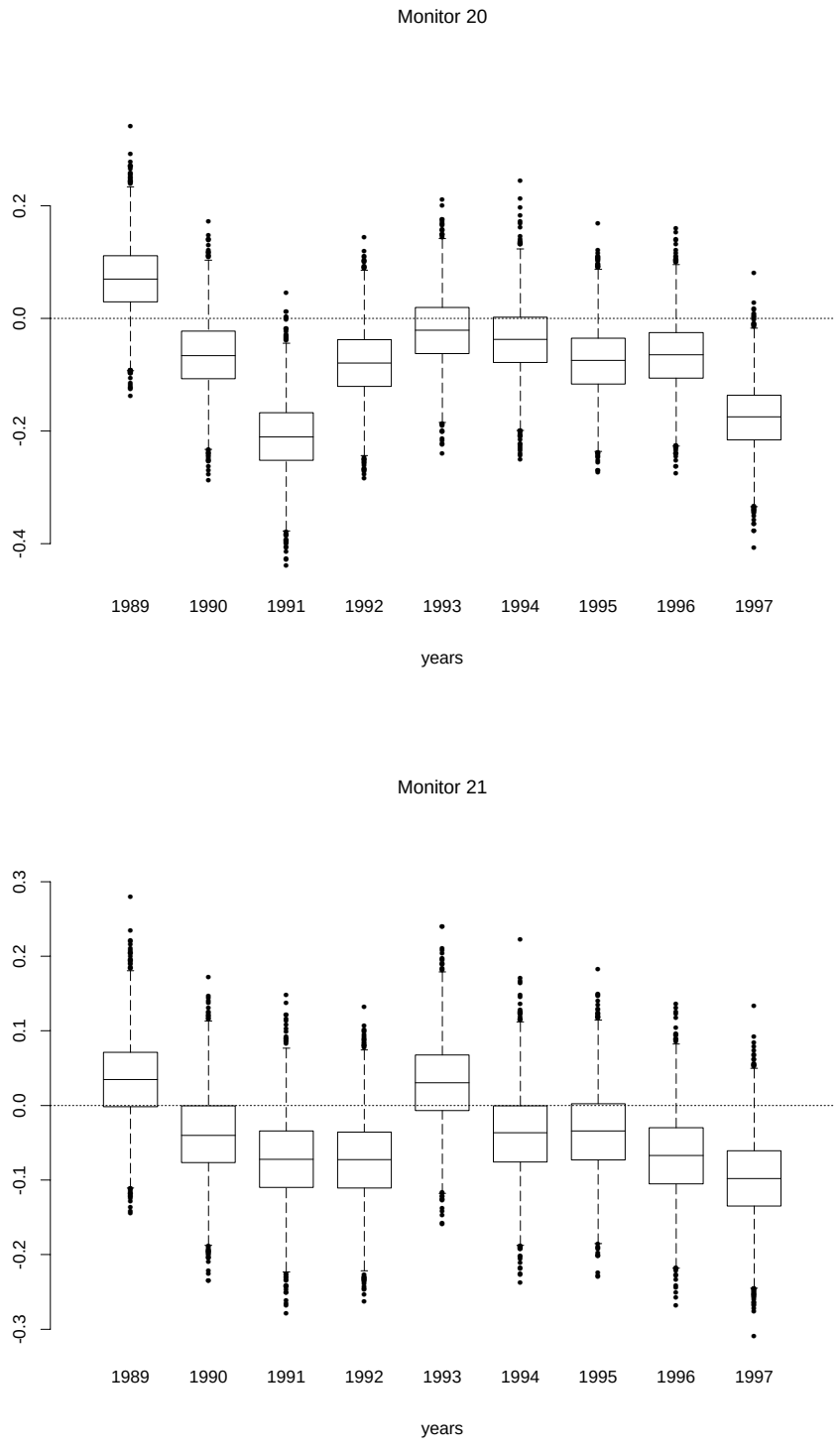

Figure 3: Posterior intervals for the *changes* in system quality level $\beta_{0t} - \beta_{0,t-1}$ over years $t = 2, \ldots, 10$. Upper frame: Monitor 20. Lower frame: Monitor 21.

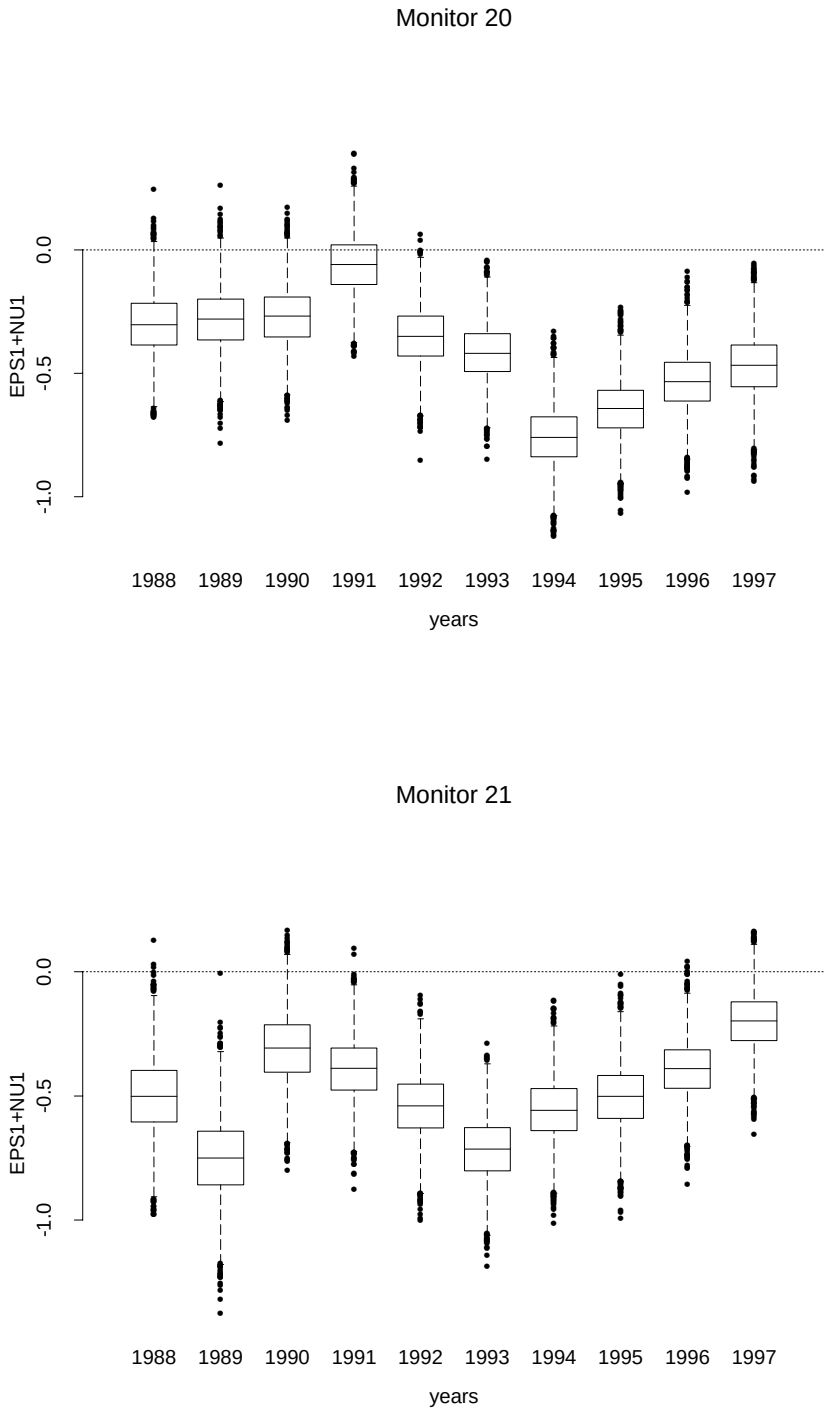

Figure 4: Posterior summaries for combined random effects $\epsilon_{it} + \nu_{it}$ in selected hospital #1. Upper frame: Monitor 20. Lower frame: Monitor 21.

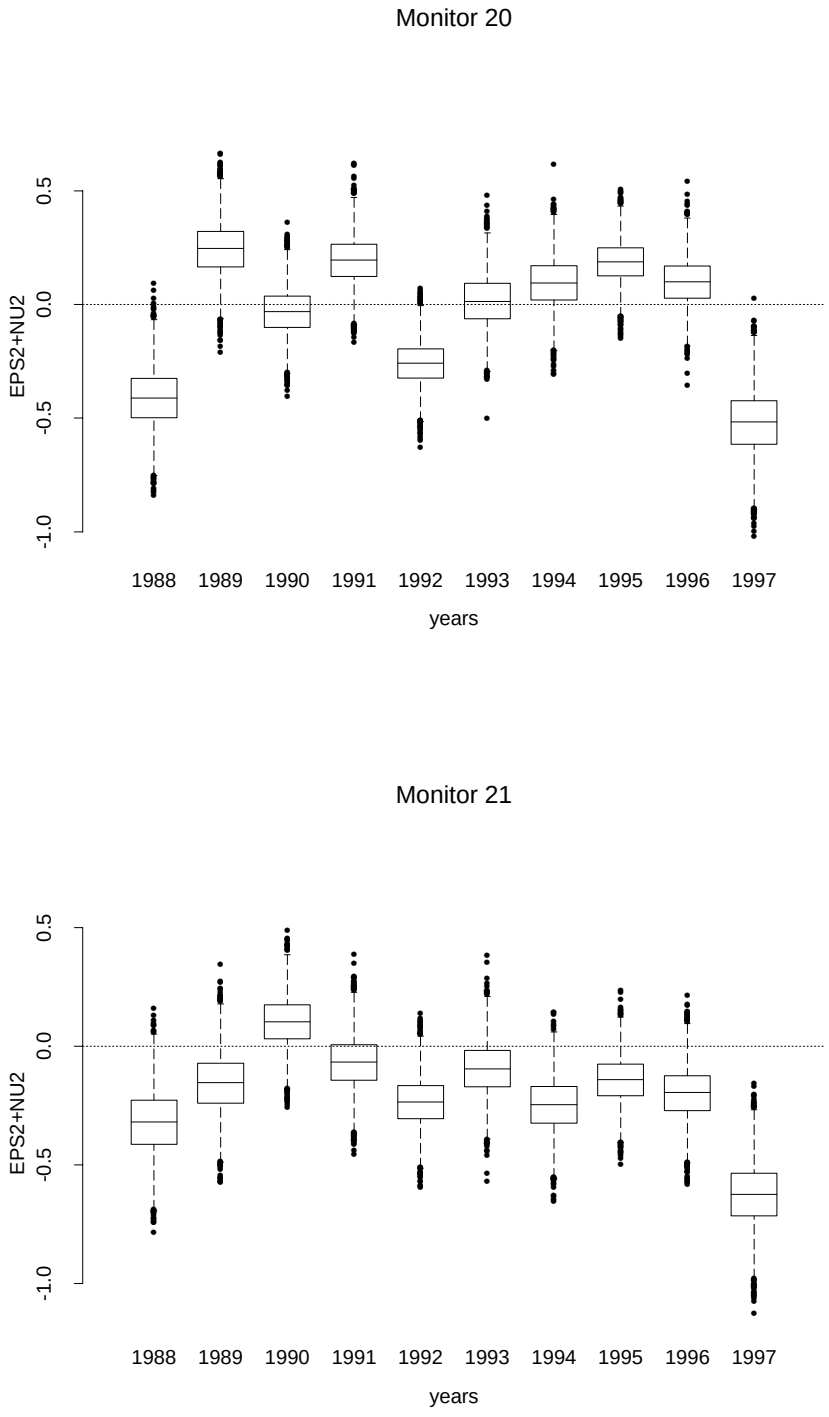

Figure 5: Posterior summaries for combined random effects $\epsilon_{it} + \nu_{it}$ in selected hospital #2. Upper frame: Monitor 20. Lower frame: Monitor 21.

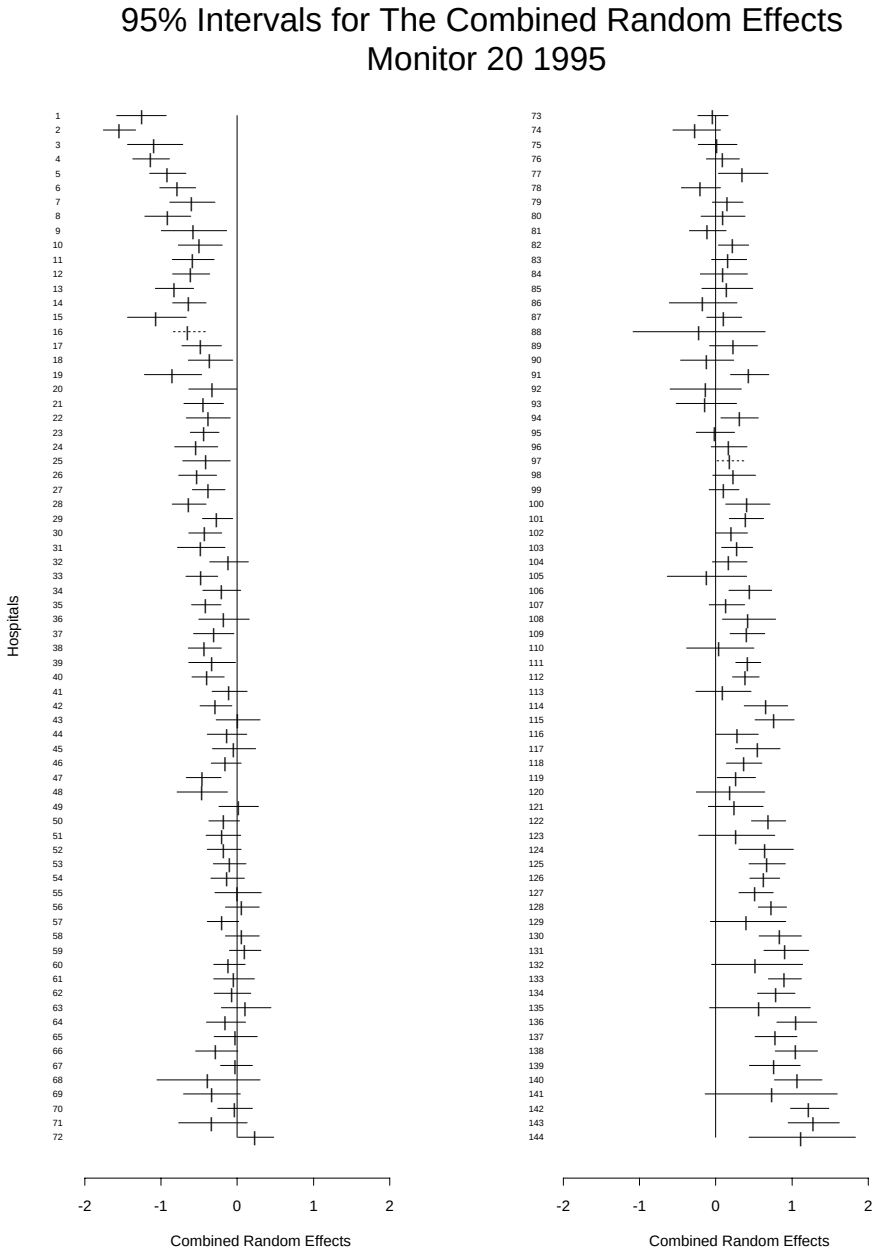

Figure 6: **Monitor 20** – Posterior intervals for combined random effects $\epsilon_{it} + \nu_{it}$ across all hospitals in 1995.

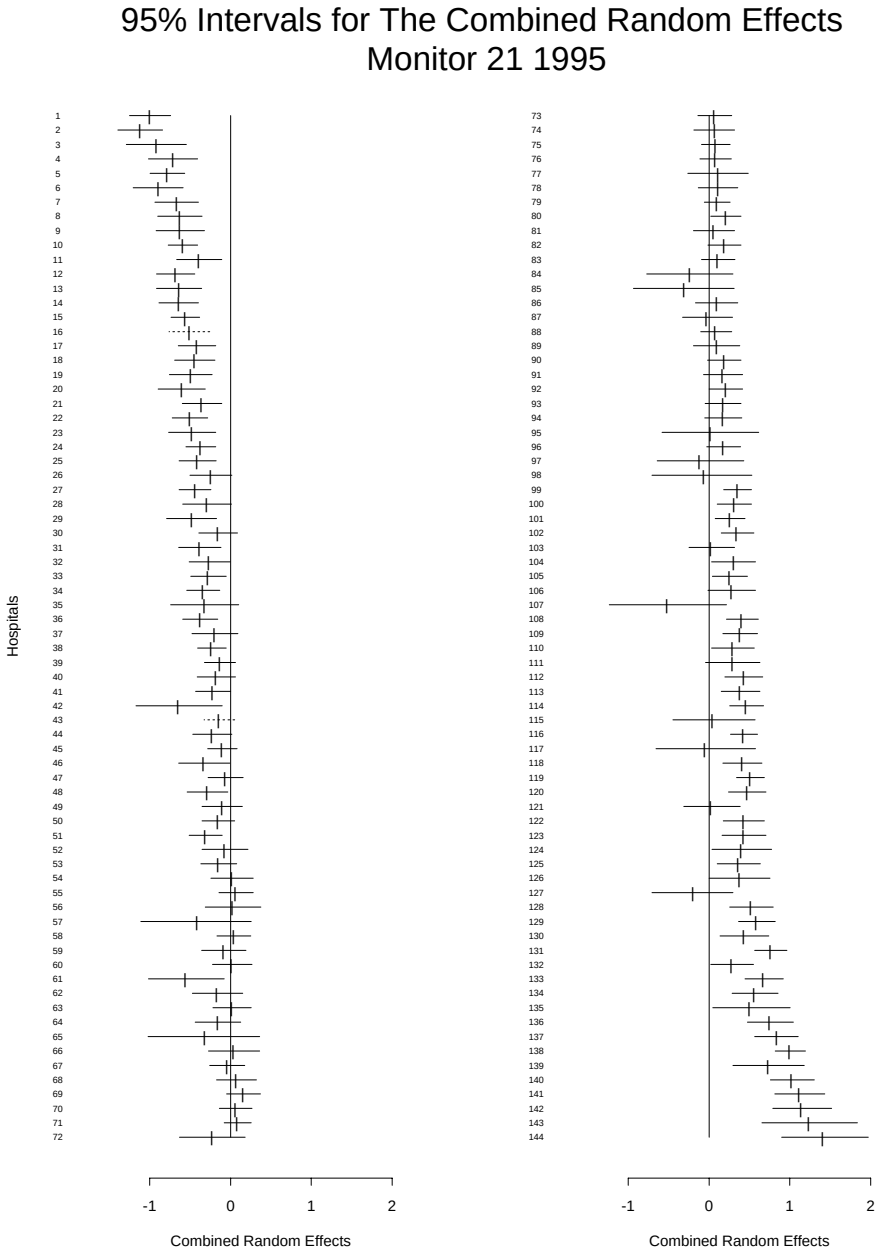

Figure 7: **Monitor 21** – Posterior intervals for combined random effects $\epsilon_{it} + \nu_{it}$ across all hospitals in 1995.