Using ITSA to examine the effectiveness of the CSU model

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What is ITSA?

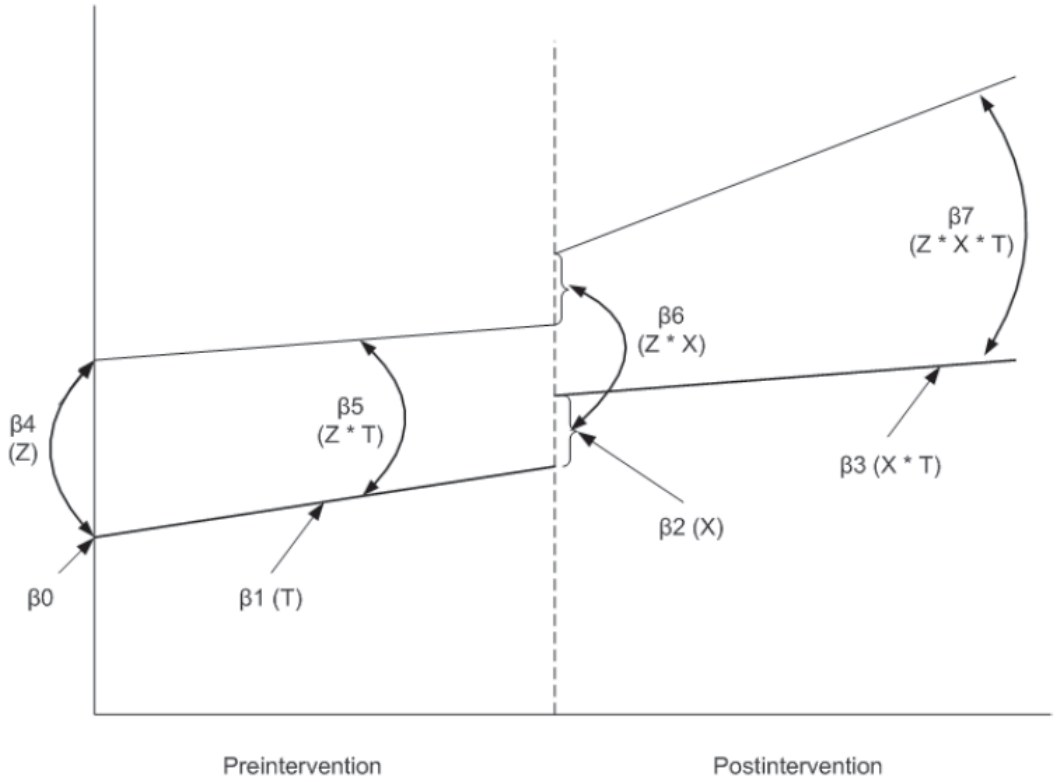


Figure 1. Visual depiction of a single group (lower line) and multiple group (upper and lower lines) interrupted time-series design, from Linden and Adams (2011)

What is ITSA?

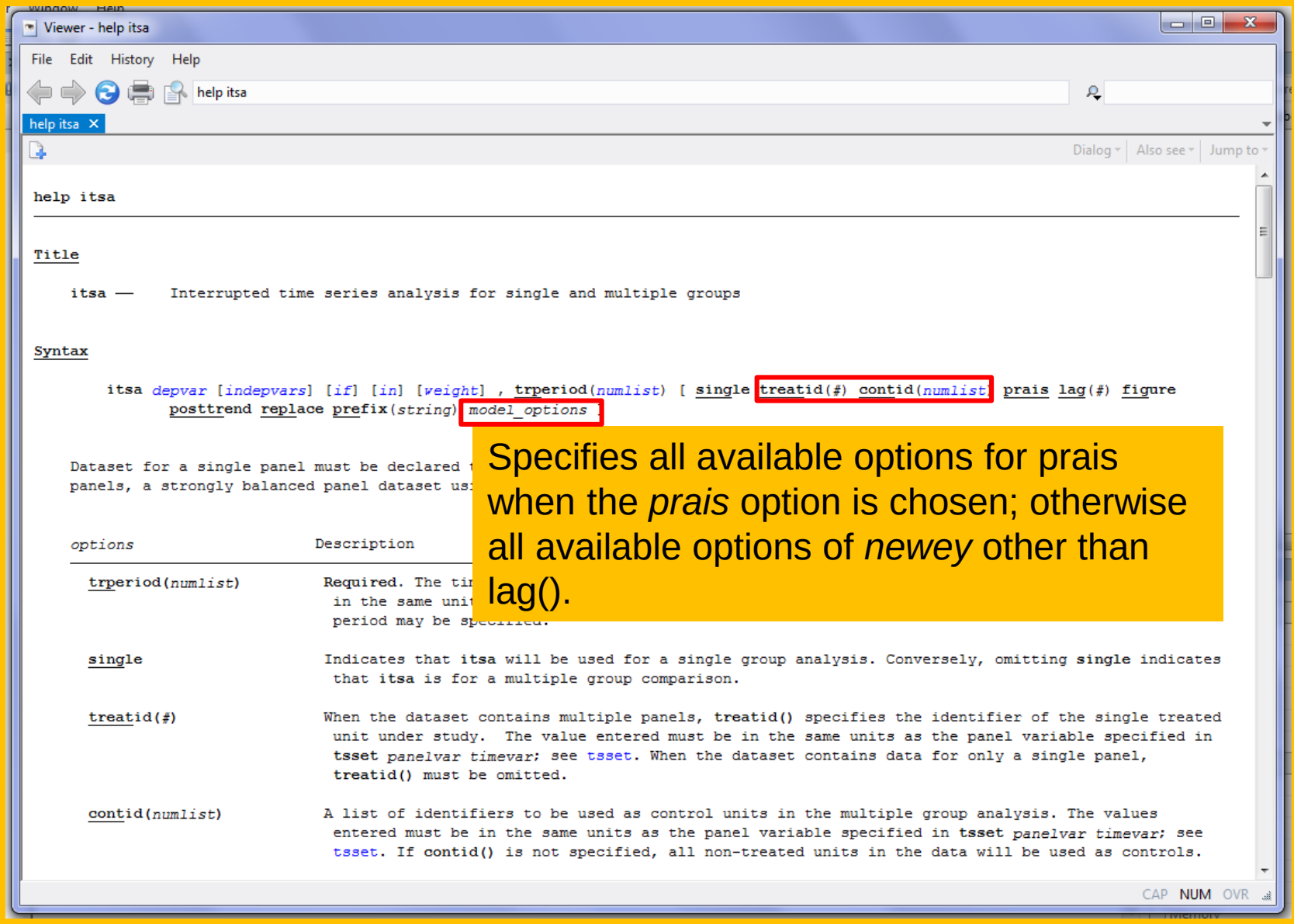
$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \epsilon_t \quad (1)$$

Y_t is the aggregated outcome variable measured at each equally spaced time point t, T_t is the time since the start of the study, X_t is a dummy (indicator) variable representing the intervention (preintervention periods 0, otherwise 1), and $X_t T_t$ is an interaction term. These terms are displayed in the lower half of figure 1. In the case of a single-group study, β_0 represents the intercept or starting level of the outcome variable. β_1 is the slope or trajectory of the outcome variable until the introduction of the intervention. β_2 represents the change in the level of the outcome that occurs in the period immediately following the introduction of the intervention (compared with the counterfactual). β_3 represents the difference between preintervention and postintervention slopes of the outcome. Thus we look for significant p-values in β_2 to indicate an immediate treatment effect, or in β_3 to indicate a treatment effect over time (Linden and Adams 2011).

Linden 2015, *Stata Journal,* 15, pp 481

Stata command: itsa

- “performs interrupted time-series analysis using two ordinary least-squares (OLS) regression-based approaches available in the official Stata packages newey and prais.” (Linden 2015)



Specifies all available options for prais when the *prais* option is chosen; otherwise all available options of *newey* other than lag().

Cochrane Group definition of an ITS design (Ramsay et al. 2003)

1. ≥ 3 time points before and after the intervention, irrespective of the statistical analysis used;
2. The intervention occurred at a clearly defined point in time;
3. The study measured provider performance or patient outcome objectively

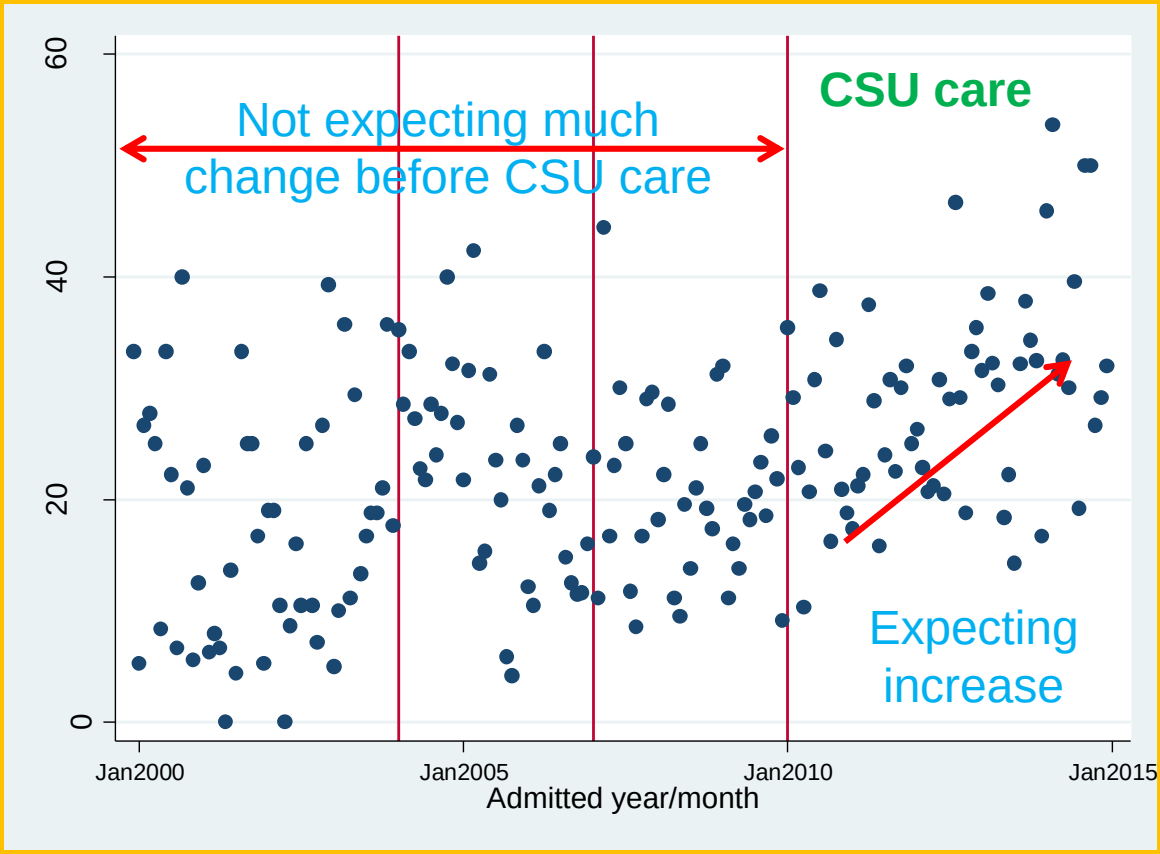
Guidelines on ITS Use (Ramsay et al, 2003)

- Intervention occurred independently of other changes over time
- Intervention was unlikely to affect data collection
- The primary outcome was assessed blindly or was measured objectively
- The primary outcome was reliable or was measured objectively
- The composition of the data set at each time point covered at least 80% of the total number of participants in the study
- The shape of the intervention effect was prespecified
- A rationale for the number and spacing of data points was described
- The study was analyzed appropriately using time series techniques

Application

- In our hospital, we currently have comprehensive stroke unit (CSU), which is the gold standard for stroke care, however, CSU is not something we always had.

- We wanted to evaluate whether the CSU results in better patients' outcomes irrespective of the physician using hospital administrative data.



Data

Add % went to rehab graph without prediction line here.

Check against guidelines

- ✓ Intervention occurred independently of other changes over time
- ✓ Intervention was unlikely to affect data collection
- ✓ The primary outcome was assessed blindly or was measured objectively
- ✓ The primary outcome was reliable or was measured objectively
- ✓ The composition of the data set at each time point covered at least 80% of the total number of participants in the study

Check against guidelines

- ✓ The shape of the intervention effect was prespecified
- ✓ A rationale for the number and spacing of data points was described
  - ✓ Monthly data was used and we had at least 10 points for each interval
- ✓ The study was analysed appropriately using time series techniques
  - ✓ The model was appropriately adjusted for auto-correlation.

Stata command & output

>itsa percrehab ***age male charlson1***, ///

sing trp(528 564 600) replace posttrend

>actest, lags(12)

Stata output

```
. itsa percrehab age male charlson1, sing trp(528 564 600) replace posttrend
        time variable:  admit_yrmo, Dec1999 to Dec2014
                delta:  1 month

Regression with Newey-West standard errors      Number of obs     =        181
maximum lag: 0                                  F( 10,       170) =       9.89
                                                Prob > F          =     0.0000
```

percrehab	Coef.	Newey-West Std. Err.	t	P>|t|	[95% Conf.	Interval]
age	-.0007322	.0025464	-0.29	0.774	-.0057589	.0042946
male	.0857055	.0831802	1.03	0.304	-.0784937	.2499047
charlson1	.0459728	.0107837	4.26	0.000	.0246856	.0672599
_t	.000686	.0010044	0.68	0.496	-.0012966	.0026686
_x528	.1360425	.0335487	4.06	0.000	.0698167	.2022683
_x_t528	-.0060821	.0013939	-4.36	0.000	-.0088336	-.0033306
_x564	.0997378	.0397674	2.51	0.013	.0212363	.1782392
_x_t564	.004457	.0016067	2.77	0.006	.0012854	.0076286
_x600	.0472935	.0298214	1.59	0.115	-.0115745	.1061615
_x_t600	.0026732	.0015231	1.76	0.081	-.0003335	.0056798
_cons	.0279082	.2255381	0.12	0.902	-.4173078	.4731241

Post-Intervention Linear Trend:

Treated: _b[_t]+_b[_x_t528]+_b[_x_t564]+_b[_x_t600]

Linear Trend	Coeff	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Treated	0.0017	0.0007	2.3885	0.0180	0.0003	0.0032

Stata output

```
. actest, lags(12)

Cumby-Huizinga test for autocorrelation (Breusch-Godfrey)
  H0: variable is MA process up to order q
  HA: serial correlation present at specified lags >q
```

H0: q=0 (serially uncorrelated) HA: s.c. present at range specified				H0: q=specified lag-1 HA: s.c. present at lag specified			
lags	chi2	df	p-val	lag	chi2	df	p-val
1 - 1	0.012	1	0.9125	1	0.012	1	0.9125
1 - 2	7.969	2	0.0186	2	7.936	1	0.0048
1 - 3	8.348	3	0.0393	3	0.392	1	0.5310
1 - 4	8.366	4	0.0791	4	0.219	1	0.6397
1 - 5	9.592	5	0.0877	5	1.658	1	0.1979
1 - 6	11.243	6	0.0812	6	1.573	1	0.2098
1 - 7	11.637	7	0.1132	7	0.013	1	0.9081
1 - 8	18.367	8	0.0186	8	3.418	1	0.0645
1 - 9	18.446	9	0.0303	9	0.099	1	0.7533
1 - 10	20.424	10	0.0255	10	0.036	1	0.8497
1 - 11	20.623	11	0.0375	11	0.050	1	0.8231
1 - 12	20.827	12	0.0530	12	1.094	1	0.2956

```
  Test allows predetermined regressors/instruments
  Test requires conditional homoskedasticity
```

Stata command & output

```
itsa percrehab age male charlson1, ///
sing trp(528 564 600) lag(2) replace posttrend
lincom _t+_x_t528
lincom _t+_x_t528+ _x_t564
lincom _t+_x_t528+ _x_t564+ _x_t600
predict res, resid
kdensity res, normal
```

Stata output

```
. itsa percrehab age male charlson1, sing trp(528 564 600) lag(2) replace posttrend
        time variable:  admit_yrmo, Dec1999 to Dec2014
                delta:  1 month

Regression with Newey-West standard errors      Number of obs     =        181
maximum lag: 2                                  F( 10,       170) =      10.25
                                                Prob > F          =     0.0000
```

percrehab	Coef.	Newey-West Std. Err.	t	P>|t|	[95% Conf.	Interval]
age	-.0007322	.0029674	-0.25	0.805	-.0065899	.0051256
male	.0857055	.0897472	0.95	0.341	-.091457	.2628679
charlson1	.0459728	.0101143	4.55	0.000	.0260069	.0659386
_t	.000686	.0007799	0.88	0.380	-.0008536	.0022255
_x528	.1360425	.0294215	4.62	0.000	.0779639	.194121
_x_t528	-.0060821	.0013619	-4.47	0.000	-.0087704	-.0033937
_x564	.0997378	.0366214	2.72	0.007	.0274465	.172029
_x_t564	.004457	.0014445	3.09	0.002	.0016056	.0073085
_x600	.0472935	.0269766	1.75	0.081	-.0059588	.1005458
_x_t600	.0026732	.0011872	2.25	0.026	.0003295	.0050168
_cons	.0279082	.2582087	0.11	0.914	-.4818001	.5376165

Post-Intervention Linear Trend:

Treated: _b[_t]+_b[_x_t528]+_b[_x_t564]+_b[_x_t600]

Linear Trend	Coeff	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Treated	0.0017	0.0006	2.7312	0.0070	0.0005	0.0030

Stata output

```
. lincom _t+_x_t528

 ( 1)  _t + _x_t528 = 0
```

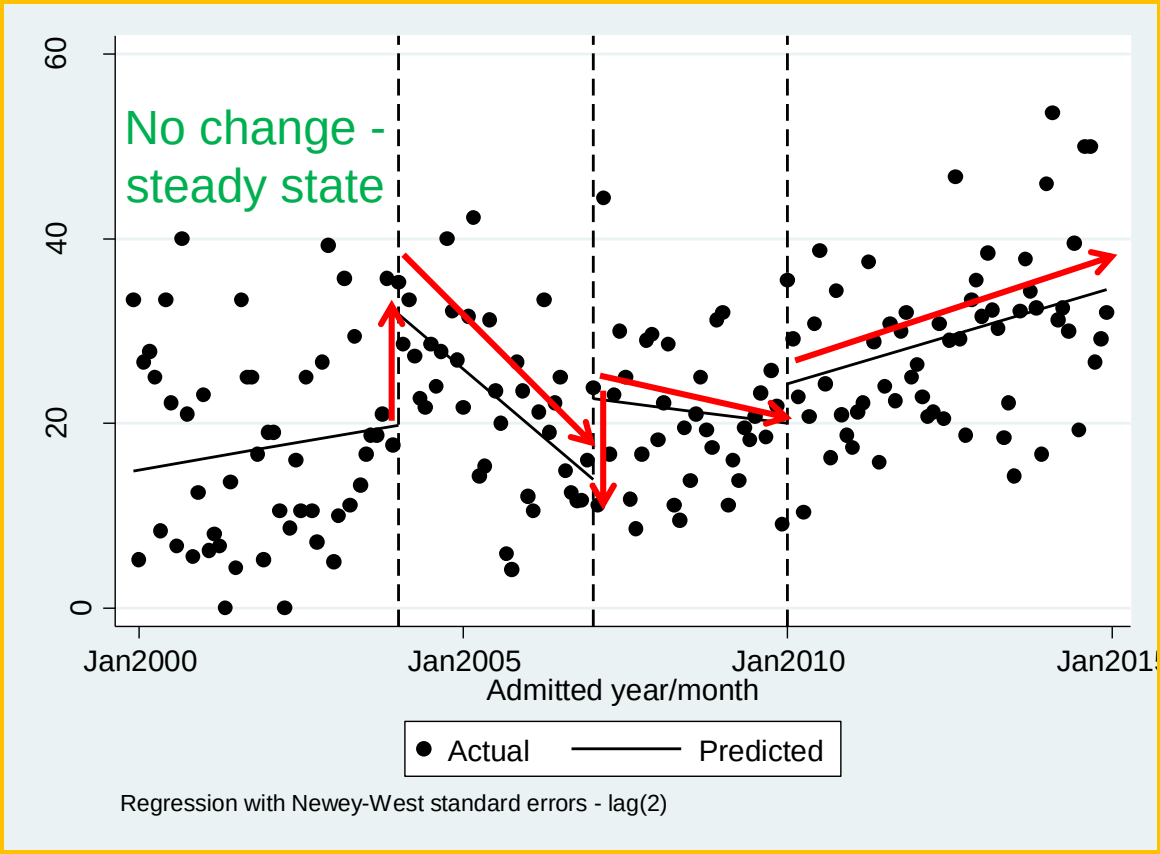
percrehab	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
(1)	-.0053961	.0010685	-5.05	0.000	-.0075054	-.0032869

```
. lincom _t+_x_t528+ _x_t564

 ( 1)  _t + _x_t528 + _x_t564 = 0
```

percrehab	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
(1)	-.0009391	.0010211	-0.92	0.359	-.0029548	.0010766

```
. lincom _t+_x_t528+ _x_t564+ _x_t600

 ( 1)  _t + _x_t528 + _x_t564 + _x_t600 = 0
```

percrehab	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
(1)	.0017341	.0006349	2.73	0.007	.0004807	.0029874



Results

Prediction line is estimated assuming median age 78 years old with 52% of males and median Charlson's comorbidity index of 3 for each month.

Results

- After the first and second change, there were immediate effect of increase in % discharged to rehabilitation ($P<0.01$), but it came back down significantly over the time post 1st change ($P<0.01$) and did not significantly change over the time post 2nd change ($P=0.359$).

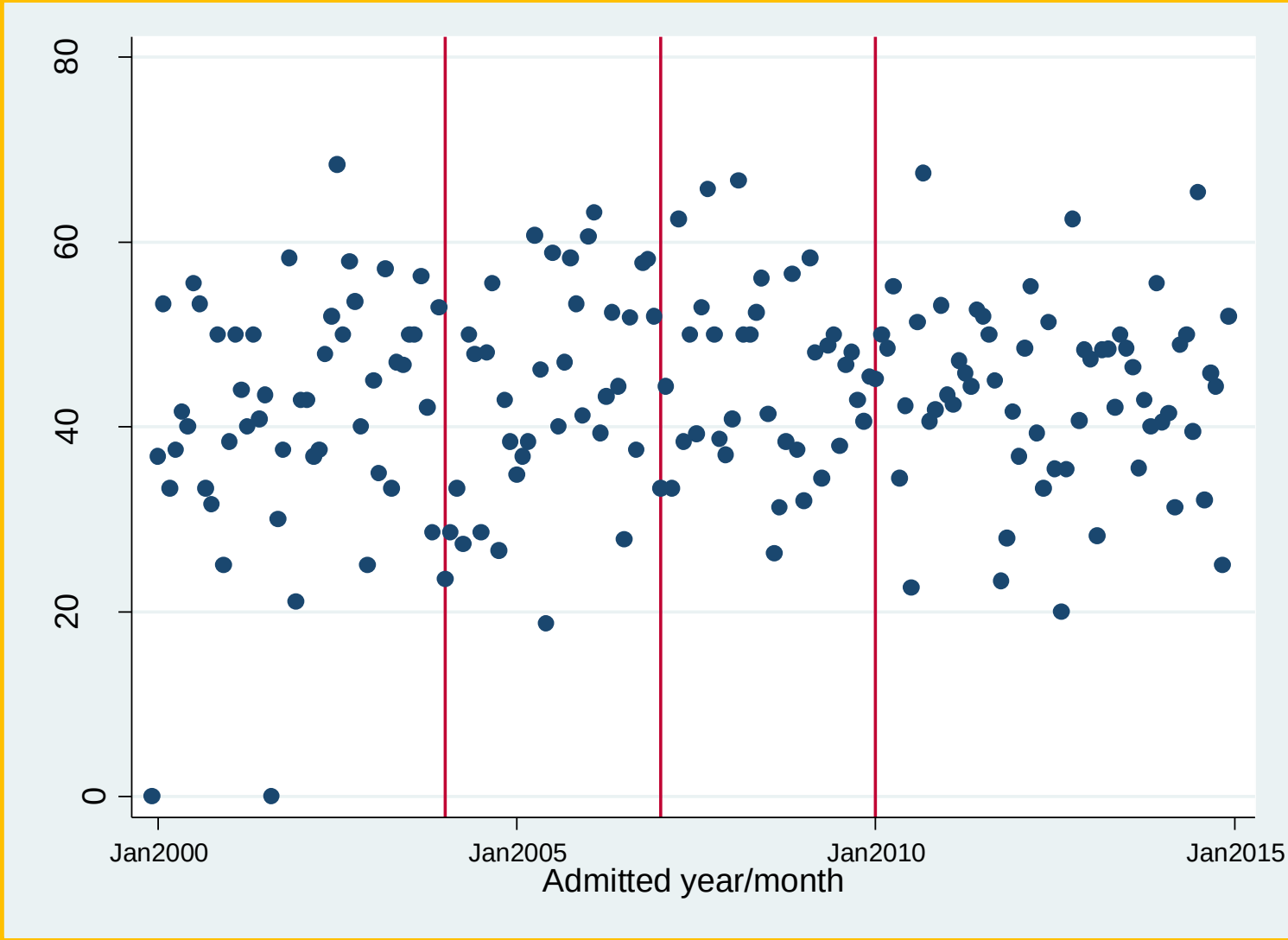
Results

- After the third change, the CSU care, although there was no significant immediate effect of increase in % discharged to rehabilitation (P=0.081), there is significant increase over the time (P<0.01)

Discussion

- We need to look at this % discharged to rehabilitation in combination with % discharged to own home and aged care facilities to be able to determine whether there's a benefit or not.

% discharged to home



Discussion

- Considering there is no change in % discharged to their own home, CSU care results better patients' outcome compared to old system.

Limitations

- Interrupted time series analysis does not consider data at the patient's level therefore can not predict the likelihood of discharge to rehabilitation at patient's level.
- The estimates of the overall effect on % discharged to rehabilitation involved extrapolation, which is inevitably associated with uncertainty.
- The regression method assumes linear trends over time.

References

1. Ramsay CR, Matowe L, Grilli R, Grimshaw JM, Thomas RE. 2003. Interrupted time series designs in health technology assessment: Lessons from two systematic reviews of behavior change strategies. *Int.J.Technol.Assess.Health Care,* 19, 613-23

2. Linden, A., and J. L. Adams. 2011. Applying a propensity-score based weighting model to interrupted time series data: Improving causal inference in program evaluation. *Journal of Evaluation in Clinical Practice,* 17, 1231–1238.

3. Linden, A. 2015. Conducting interrupted time-series analysis for single- and multiple-group comparisons. *Stata Journal,* 15**,** 480-500.

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