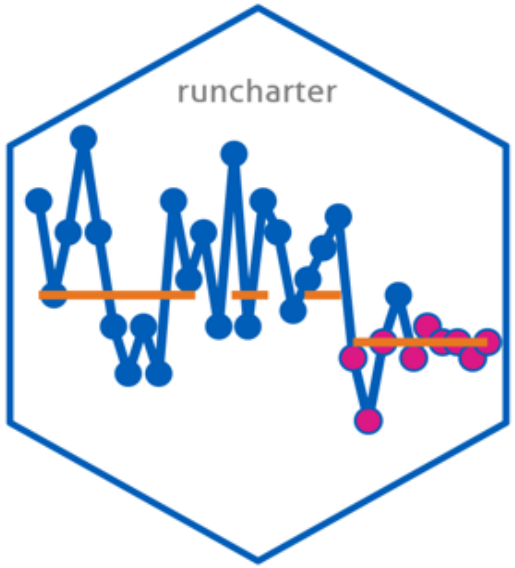
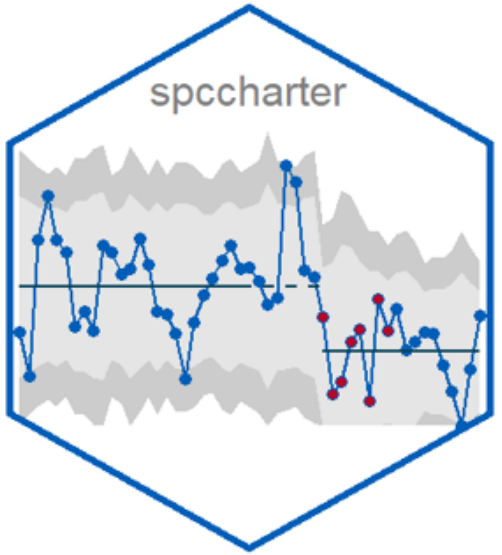
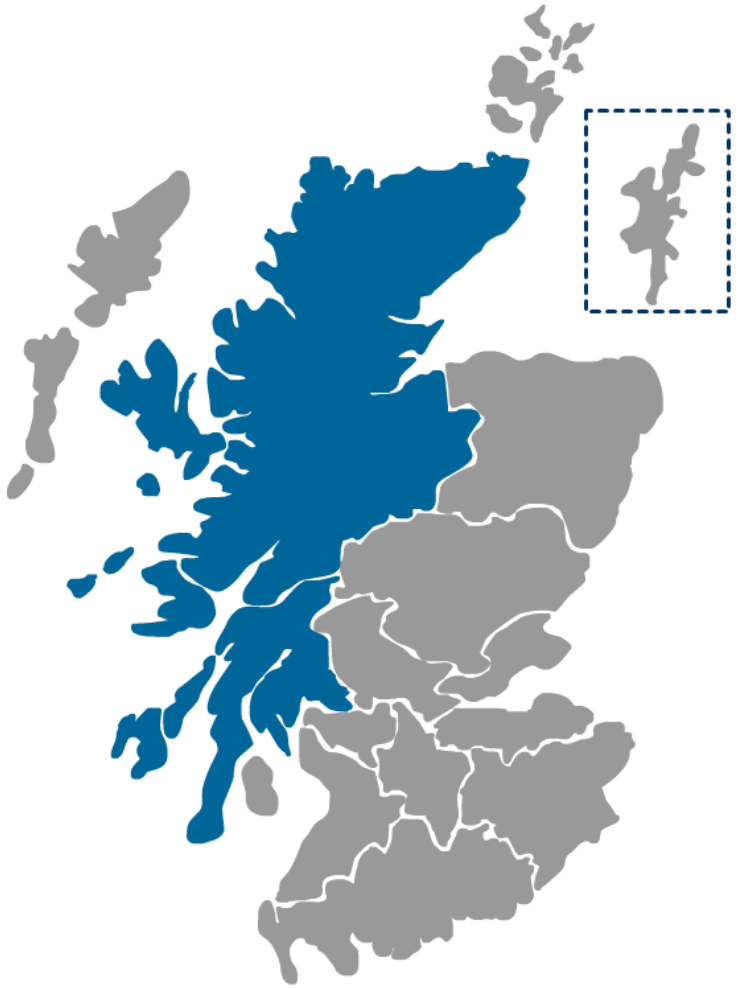
Rapid analysis and presentation of Quality Improvement data with R





John MacKintosh

Background



National overarching Patient Safety Programme

Adult, Mental Health, Primary Care, Paediatrics, Maternity
Several Workstreams per programme

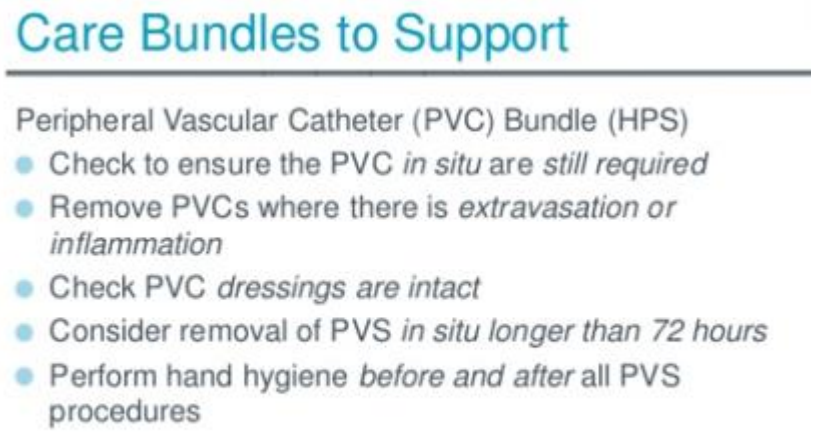
Multiple measures per workstream

Remote and Rural area spanning 40% of Scotland's land mass

30 Hospitals, 100 GP practices, 80 frontline ward areas

Run Charts

- Mainly used for process data (e.g. care or safety bundles)
- Simple, easy to construct – can be drawn and updated at frontline
- Run chart rules tell us if the changes we are making are bringing about the desired improvement



Care Bundles to Support

Peripheral Vascular Catheter (PVC) Bundle (HPS)

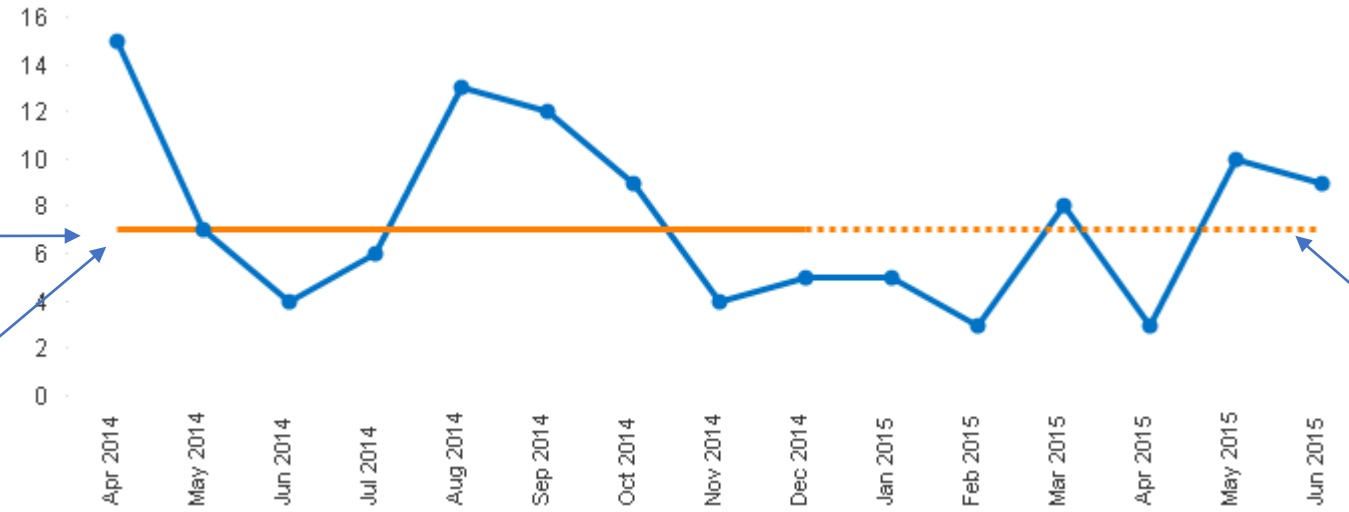
- Check to ensure the PVC *in situ* are *still required*
- Remove PVCs where there is *extravasation or inflammation*
- Check PVC *dressings are intact*
- Consider removal of PVS *in situ longer than 72 hours*
- Perform hand hygiene *before and after* all PVS procedures

Anatomy of a run chart

Y axis is the measure of interest – count, % compliance with safety bundle etc.

Median value

Solid line denotes original baseline period

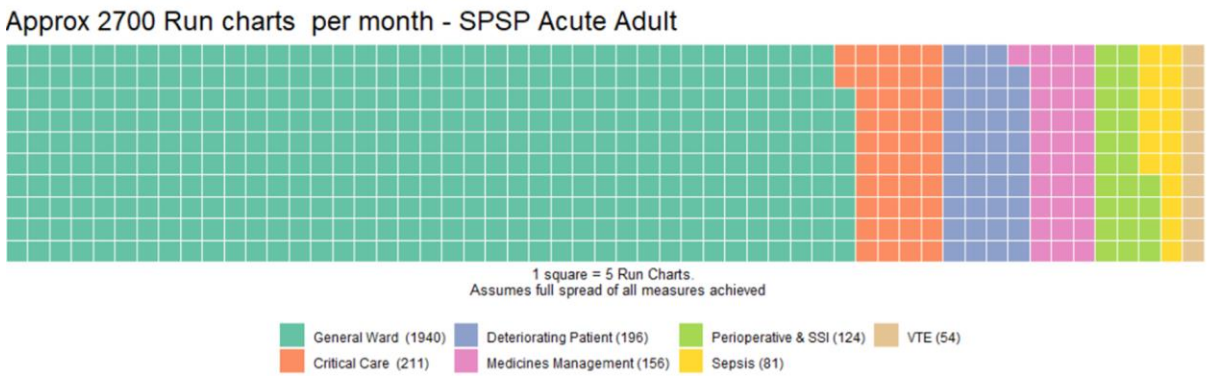


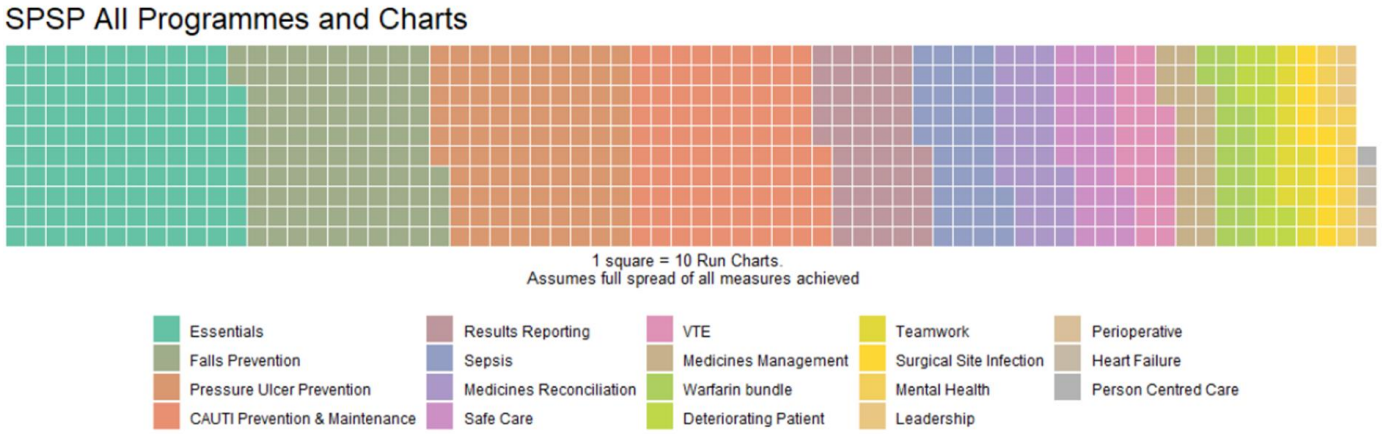
Extended median for analysis using run chart rules

X axis - Data plotted in time order

A ‘run’ is 1 or more consecutive data points on the same side of the median

Potential Charts required





Care Bundles to Support

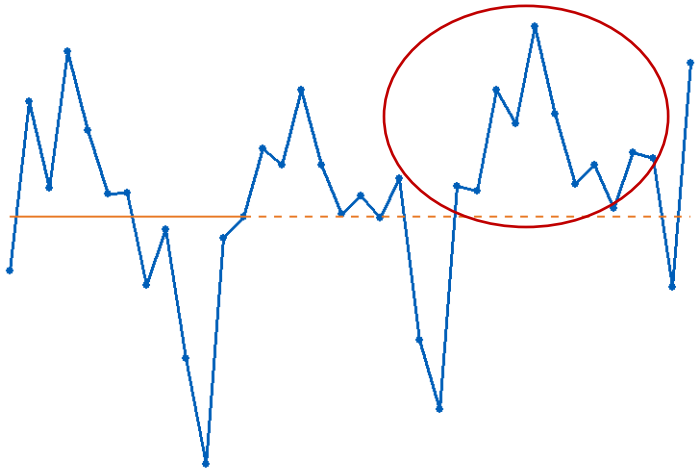
Peripheral Vascular Catheter (PVC) Bundle (HPS)

- Check to ensure the PVC *in situ* are *still required*
- Remove PVCs where there is *extravasation or inflammation*
- Check PVC *dressings are intact*
- Consider removal of PVS *in situ longer than 72 hours*
- Perform hand hygiene *before and after* all PVS procedures

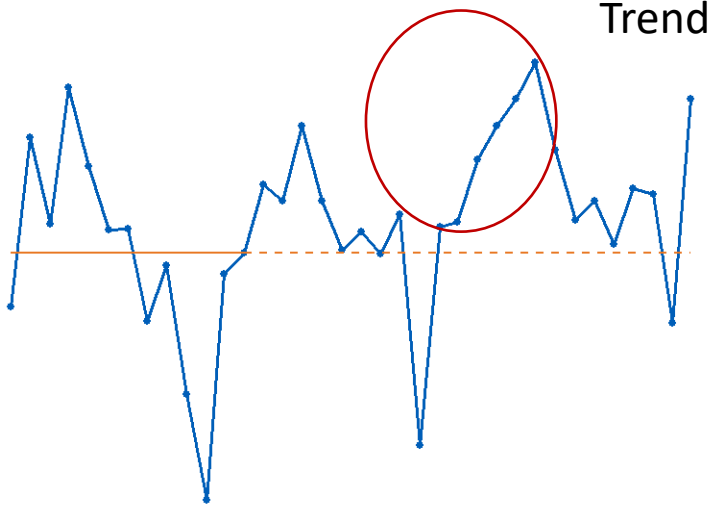
- Care bundles require 1 chart for each element, plus one for overall compliance
- This bundle requires 6 charts

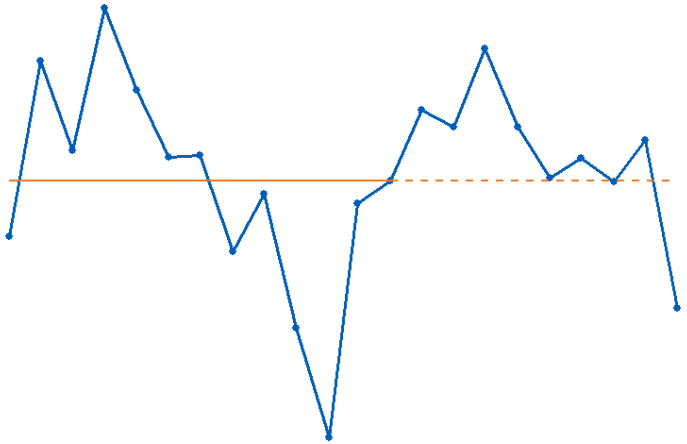
Run Chart Rules

Shift

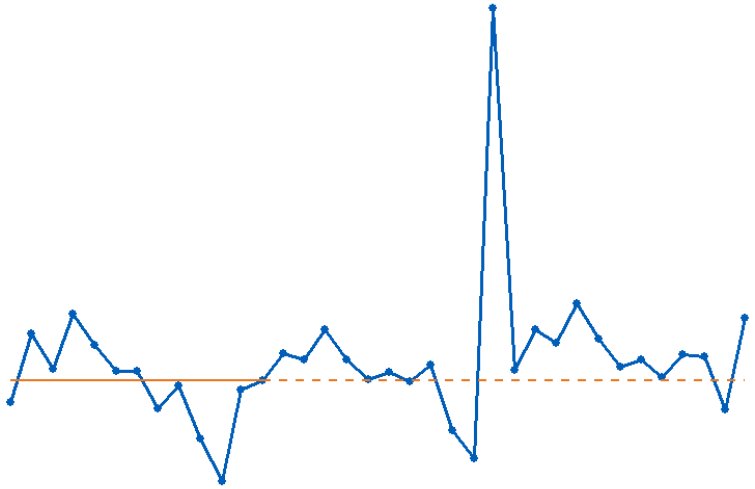


Trend





Too few /too many runs

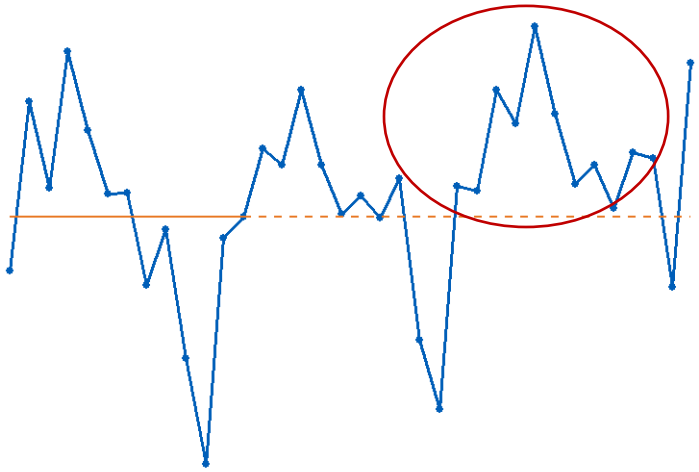


Astronomical data point

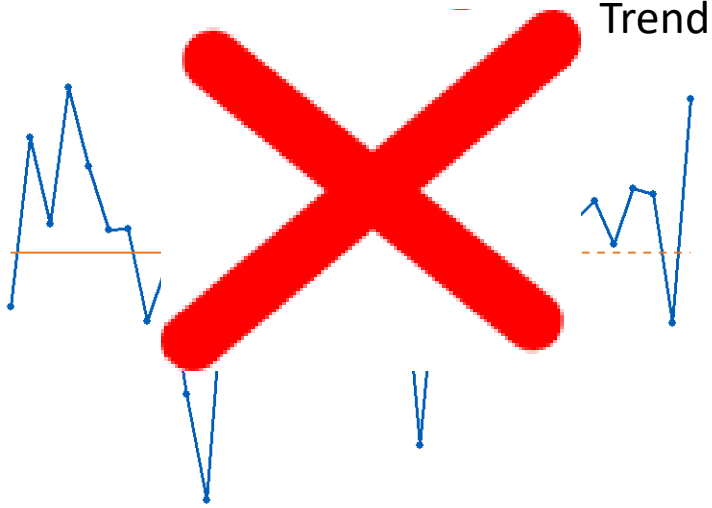
- Shift – 6 or more consecutive points on one side of the median
- Trend 5 or more consecutively increasing or decreasing points (regardless of the median)
- Tables to determine too few / too many runs

Run chart rules - critiques

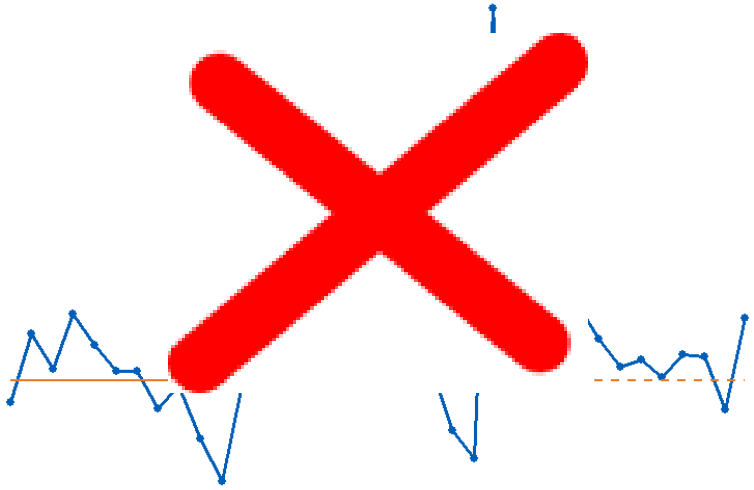
Shift



Trend



Too few / too many runs



Astronomical data point

"trend rule .. virtually useless"
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0113825

Astronomical data point - vague

Too many runs will never be a signal of improvement

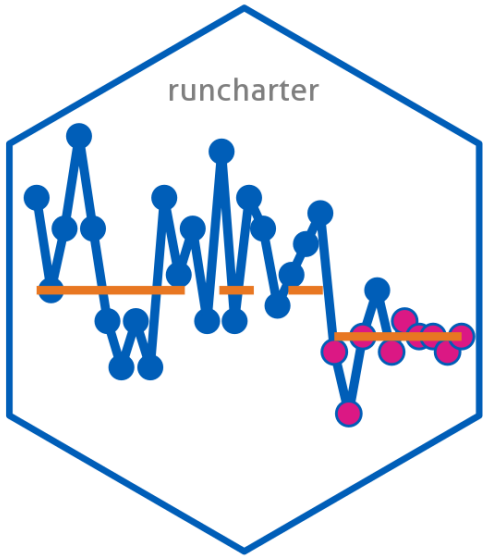
qicharts2 package detects signals based on modified 'too few runs' rule : https://github.com/anhoej/qicharts2

Challenges

- Analytical
- Visual / Reporting

- Points on the median do not make or break a run
- Eyeballing the data was time consuming and not viable in long term
- Spreadsheet analysis cumbersome
- SQL not ideally suited to row by row analysis
- My RDBMS did not have a median function
- Excel dashboards – Unreliable / exporting issues
- BI reporting tools – cumbersome, not designed for this sort of analysis

runcharter



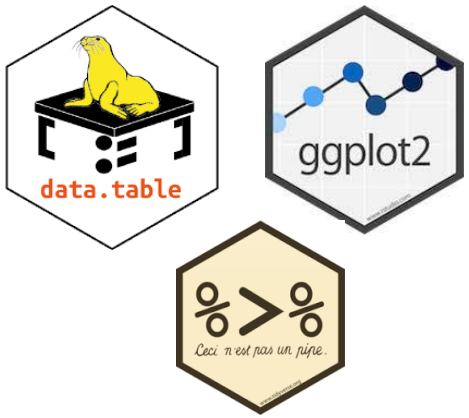
Calculates baseline medians ✓

Finds sustained runs of improvement in desired direction ✓

Calculates new median when a run occurs ✓

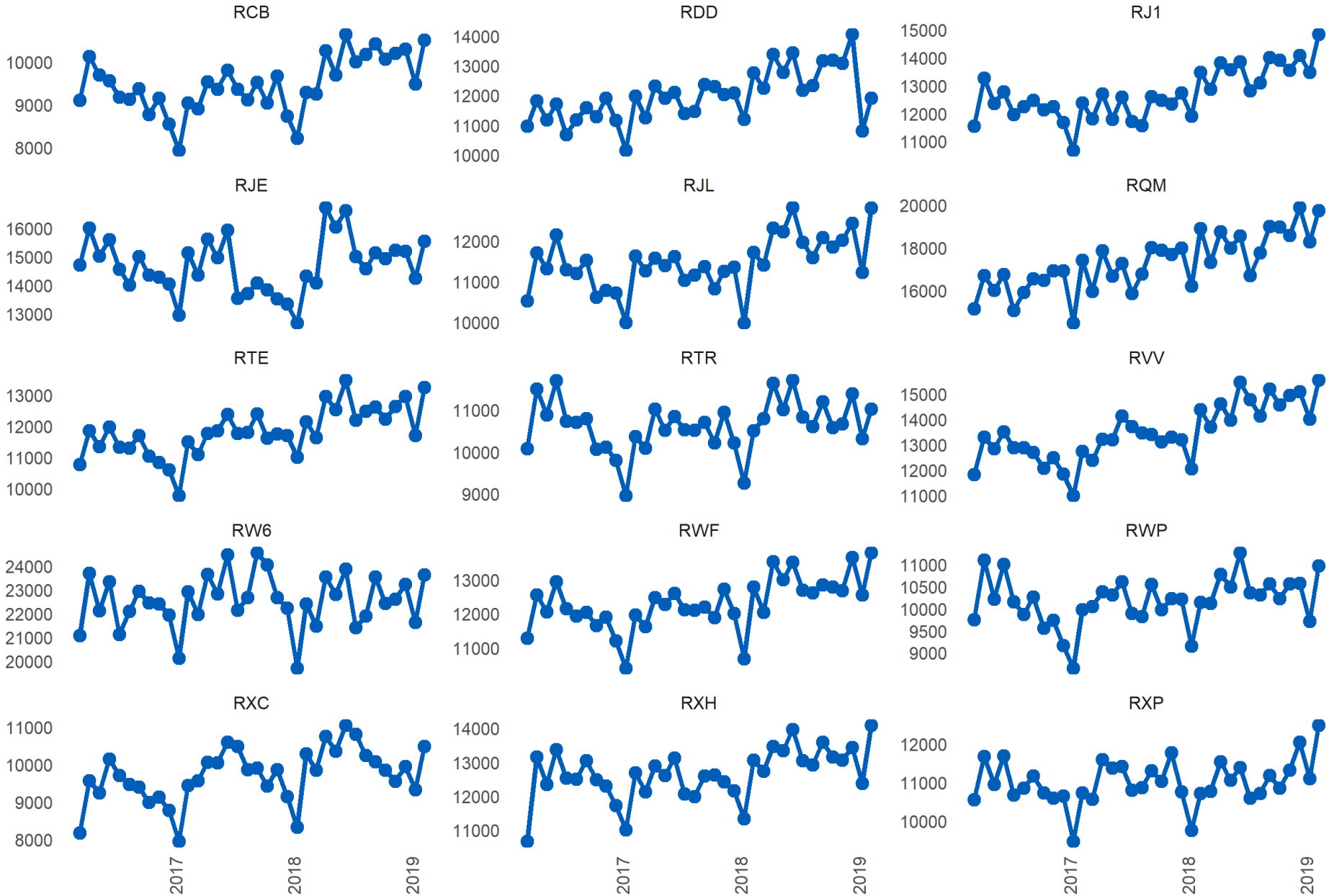
Finds additional runs based on new median ✓

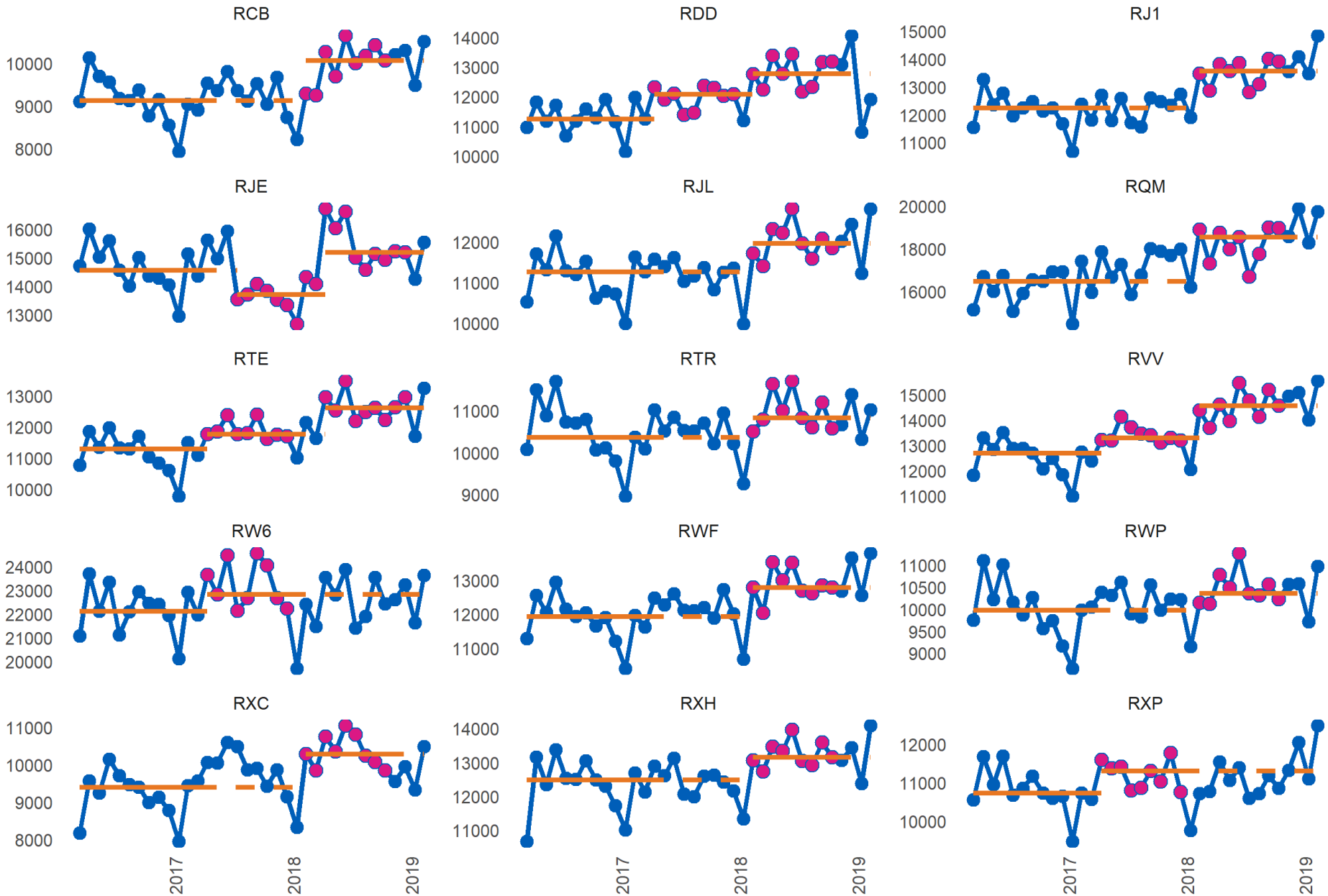
Returns plot & data ✓



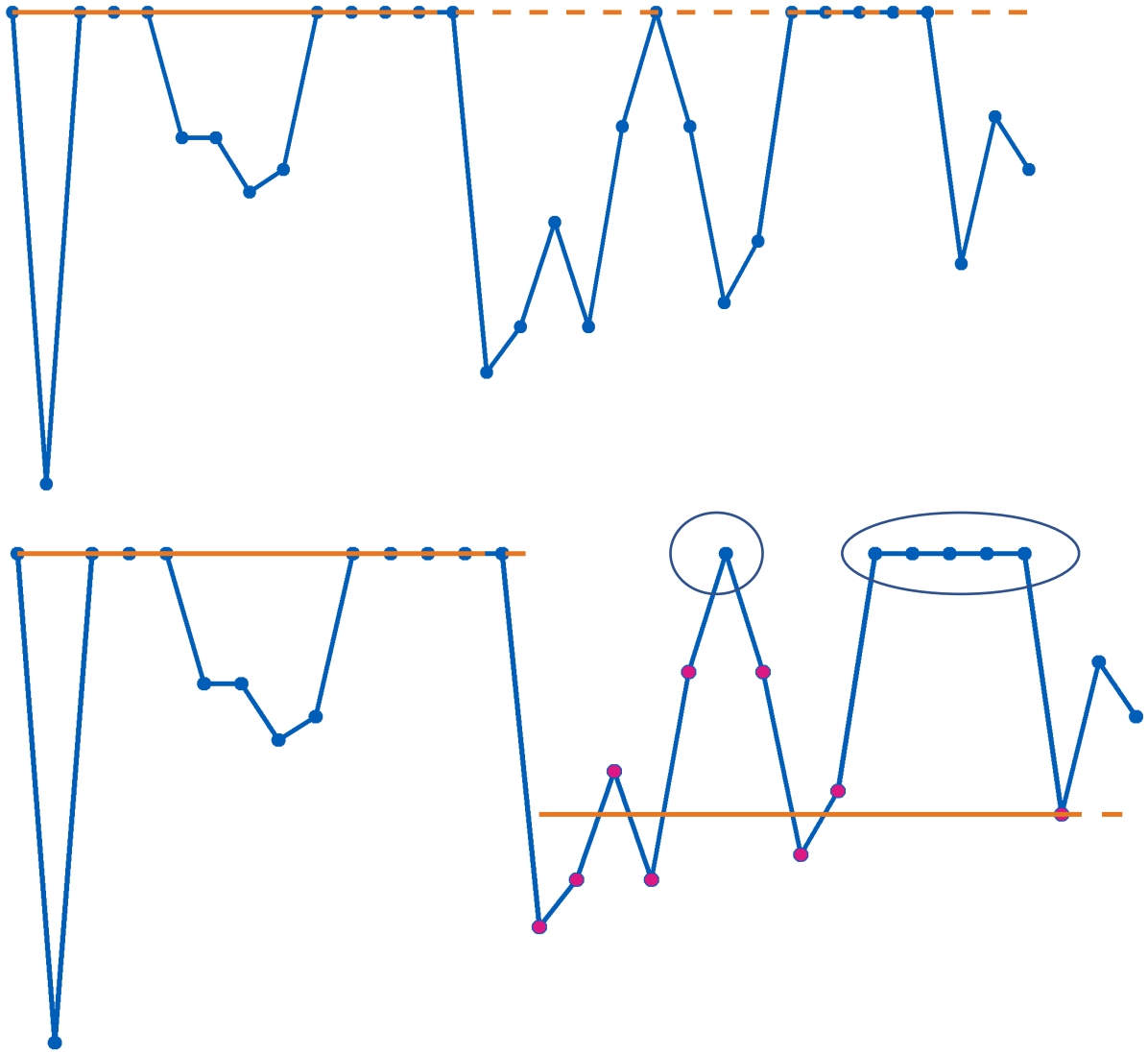
https://github.com/johnmackintosh/runcharter

Package site and vignettes:
https://johnmackintosh.com/runcharter/


RCB
10000
9000
8000
RDD
14000
13000
12000
11000
10000
RJ1
15000
14000
13000
12000
11000
RJE
16000
15000
14000
13000
RJL
12000
11000
10000
RQM
20000
18000
16000
RTE
13000
12000
11000
10000
RTR
11000
10000
9000
RVV
15000
14000
13000
12000
11000
RW6
24000
23000
22000
21000
20000
RWF
13000
12000
11000
RWP
11000
10500
10000
9500
9000
RXC
11000
10000
9000
8000
RXH
14000
13000
12000
11000
RXP
12000
11000
10000
2017
2018
2019

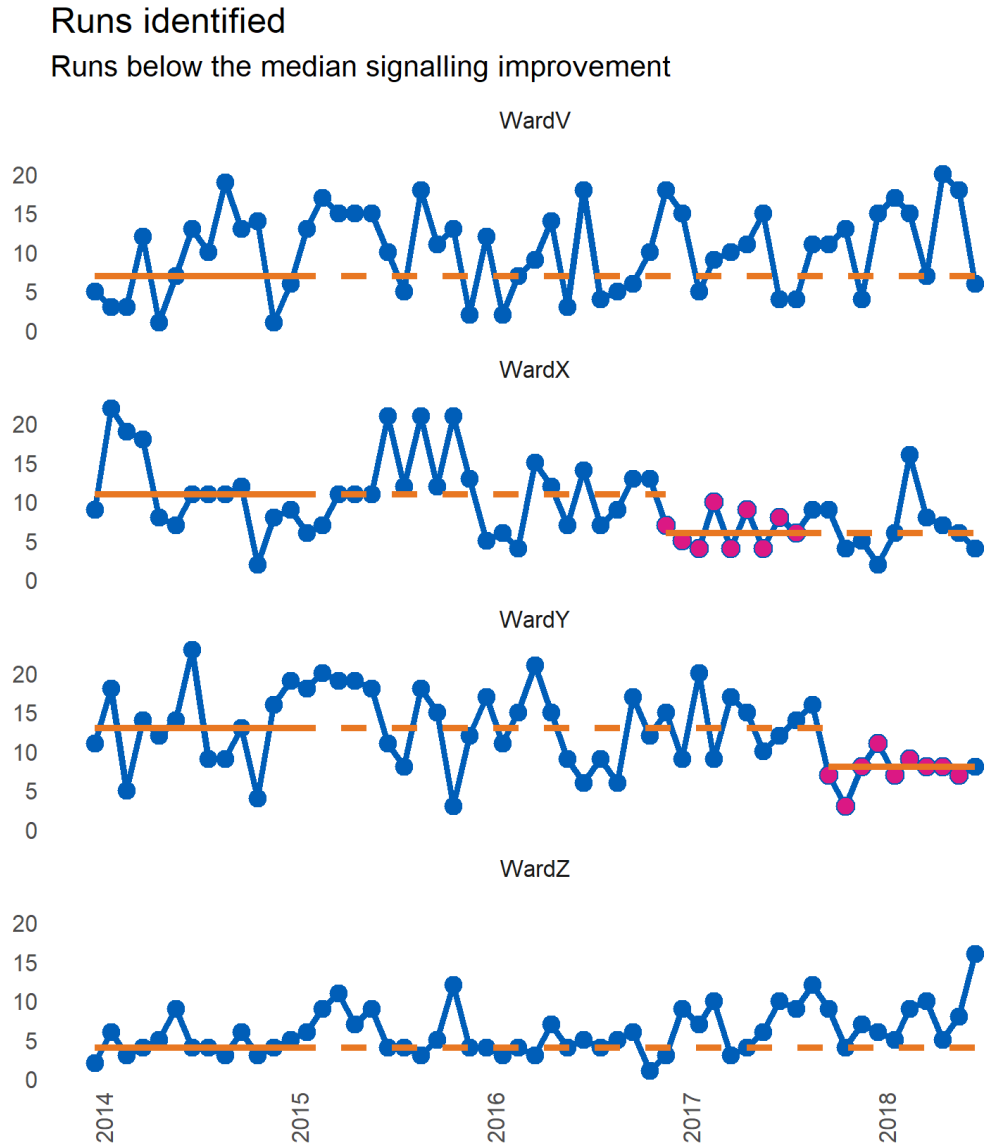

RCB
10000
9000
8000
RDD
14000
13000
12000
11000
10000
RJ1
15000
14000
13000
12000
11000
RJE
16000
15000
14000
13000
RJL
12000
11000
10000
RQM
20000
18000
16000
RTE
13000
12000
11000
10000
RTR
11000
10000
9000
RVV
15000
14000
13000
12000
11000
RW6
24000
23000
22000
21000
20000
RWF
13000
12000
11000
RWP
11000
10500
10000
9500
9000
RXC
11000
10000
9000
8000
RXH
14000
13000
12000
11000
RXP
12000
11000
10000
2017
2018
2019

Points on median do not make or break a run



```
library(runcharter)

runcharter(signals,
           direction = "below",
           datecol = "date",
           grpvar = "grp",
           yval = "y",
          chart_title = " Runs identified",
          chart_subtitle = "Runs below the median signalling improvement")
```

```
#> $sustained
#>      grp median start_date   end_date  extend_to  run_type
#> 1: WardV      7 2014-01-01 2015-01-01 2018-07-01  baseline
#> 2: WardX     11 2014-01-01 2015-01-01 2016-12-01  baseline
#> 3: WardY     13 2014-01-01 2015-01-01 2017-10-01  baseline
#> 4: WardZ      4 2014-01-01 2015-01-01 2018-07-01  baseline
#> 5: WardX      6 2016-12-01 2017-08-01 2018-07-01 sustained
#> 6: WardY      8 2017-10-01 2018-06-01 2018-07-01 sustained
```



```r
runcharter(df,
  med_rows = 13,
  runlength = 9,
  direction = c("above", "below", "both"),
  datecol = NULL,
  grpvar = NULL,
  yval = NULL,
  facet_cols = NULL,
  facet_scales = "fixed",
  chart_title = NULL,
  chart_subtitle = NULL,
  chart_caption = NULL,
  chart_breaks = NULL,
  line_colr = "#005EB8",
  line_size = 1.1,
  point_colr = "#005EB8",
  point_size = 2.5,
  median_colr = "#E87722",
  median_line_size = 1.05,
  highlight_fill = "#DB1884",
  highlight_point_size = 2.7,
  ...
)
```

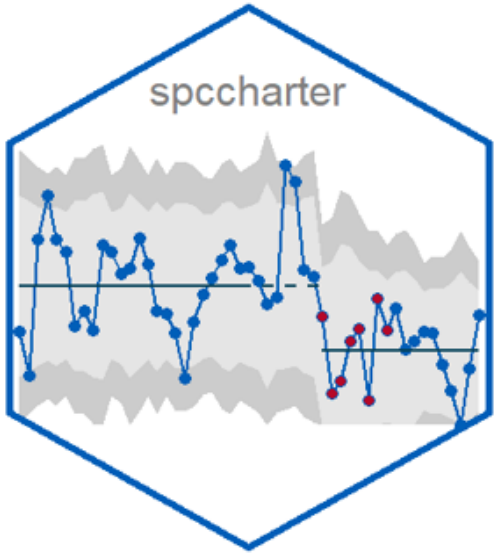
- Pipe friendly
- Length of initial median
- Length of run
- Direction – above, below or both
- Number of facets
- Fixed or free scale y axis
- Date column axis breaks
- Chart appearance – line, centre line, point and highlight size and colours

You shouldn’t revise limits automatically?

- Quality improvement data
- Facilitators actively bringing about change
- Motivates frontline teams to see change in median
- Signal from noise

spccharter

https://github.com/johnmackintosh/spccharter



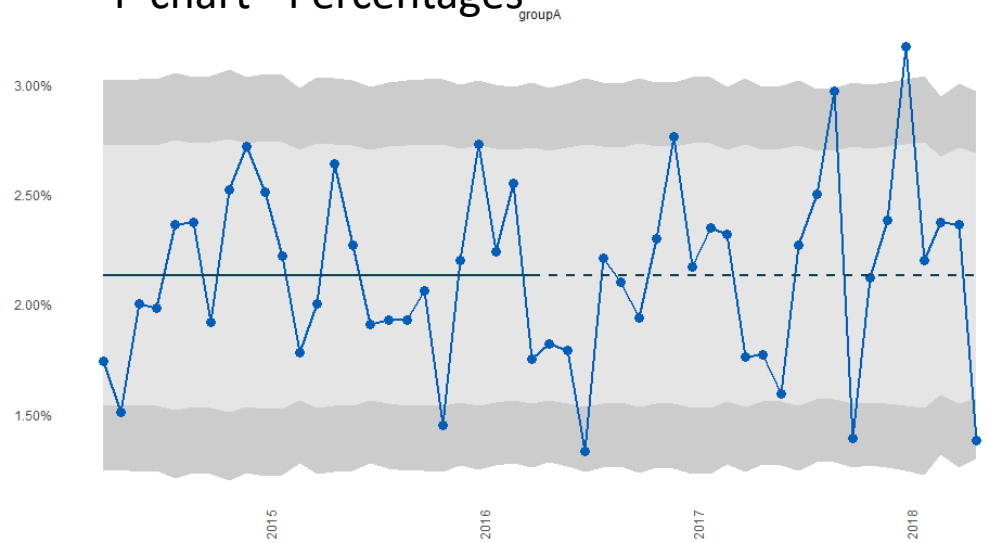
“runcharter, but for SPC charts”

SPC more robust, longer term assurance and useful for outcome and balancing measures

Highlights first 8 points of run, and recalculates new limits based on the ‘look_forward’ parameter.

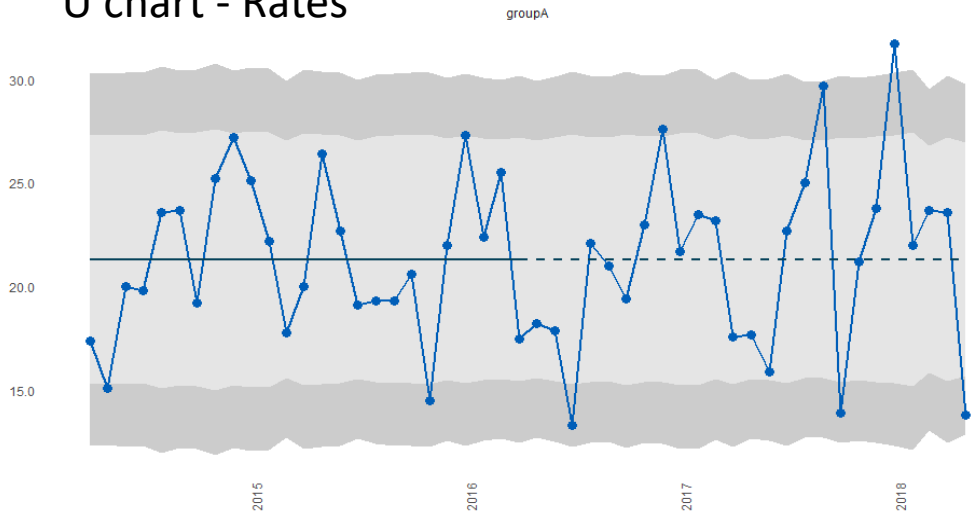
```
# p chart
spccharter(test2,
           numerator = defects,
           denominator = possible,
           datecol = report_month,
           by = testgroup,
           plot_type = 'p',
           direction = 'both')
```

P chart - Percentages



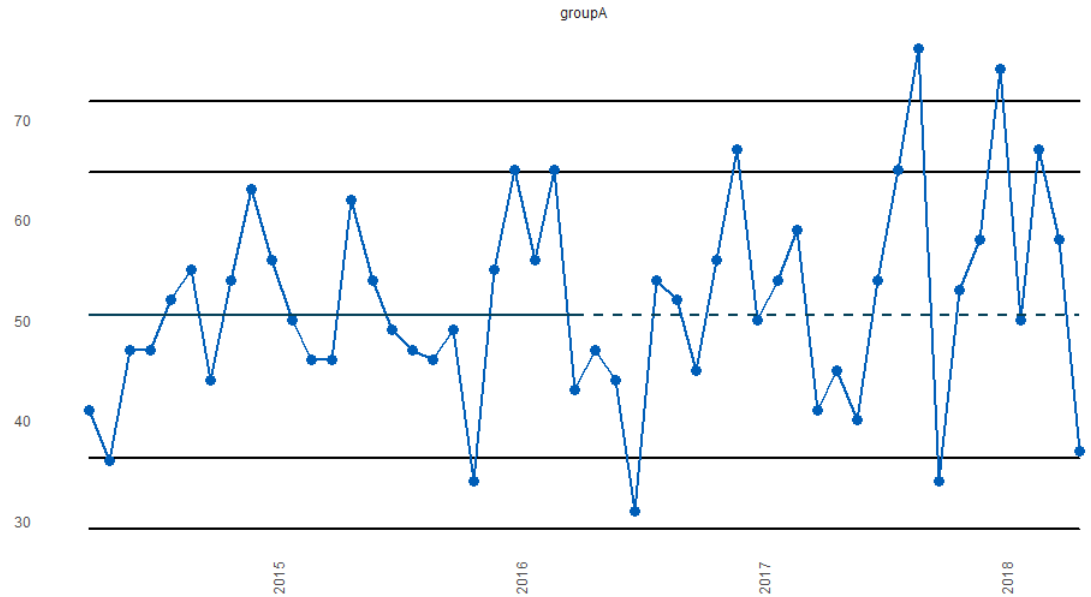

```
# u chart
spccharter(test2,
           numerator = defects,
           denominator = possible,
           datecol = report_month,
           by = testgroup,
           plot_type = 'u',
           direction = 'both',
           multiplier = 1000)
```

U chart - Rates



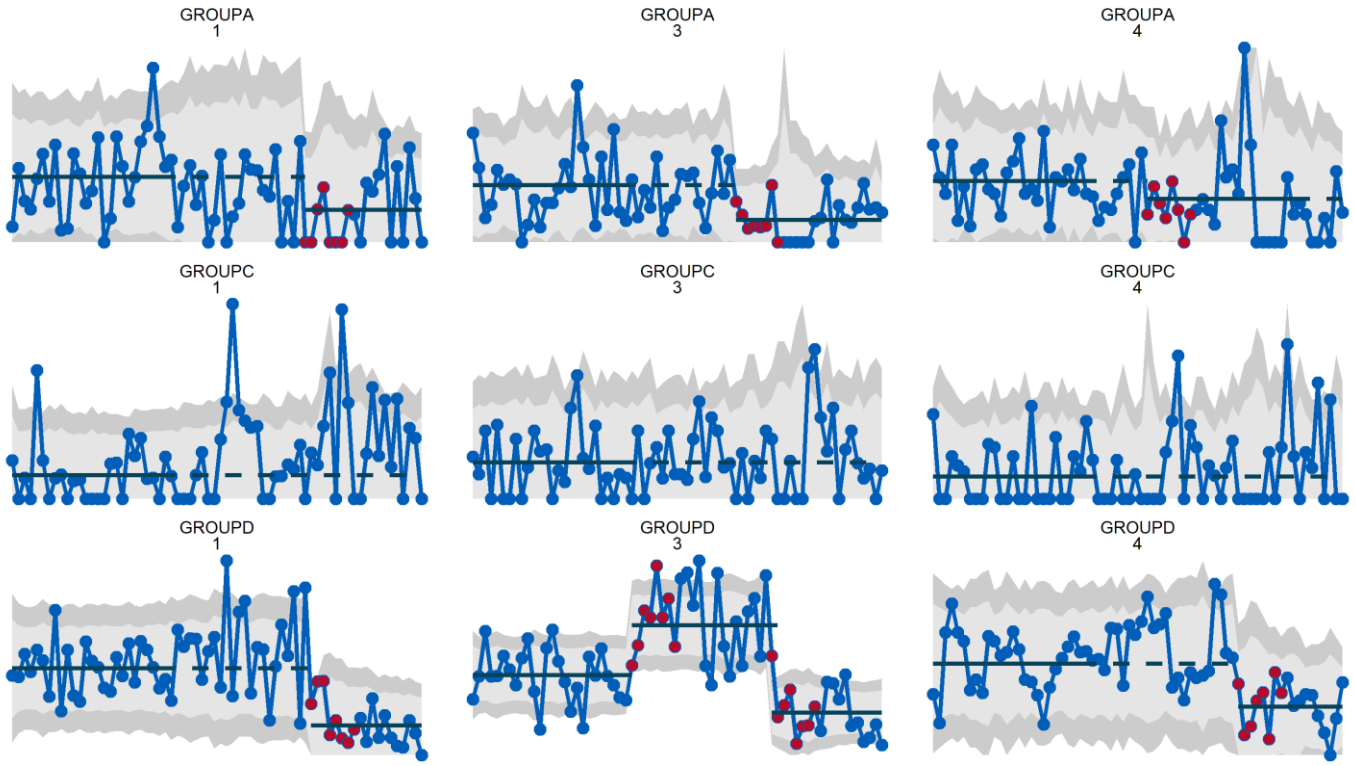
```
#  c chart
spccharter(test2,
           numerator = defects,
           denominator = possible, # ignored if plot_type = 'c'
           datecol = report_month,
           by = testgroup,
           plot_type = 'c',
           direction = 'both',
           cl_fill = 'white',
           wl_fill = 'white',
           cl_colr = 'black',
           wl_colr = 'black')
```

C chart - counts



spccharter – small multiples

```
spccharter(test_df1,
           numerator = fail,
           denominator = possible,
           datecol = report_date,
           by = c('group','subgroup'),
           plot_type = 'p',
           direction = 'both',
           facet_scales = 'free_y')
```



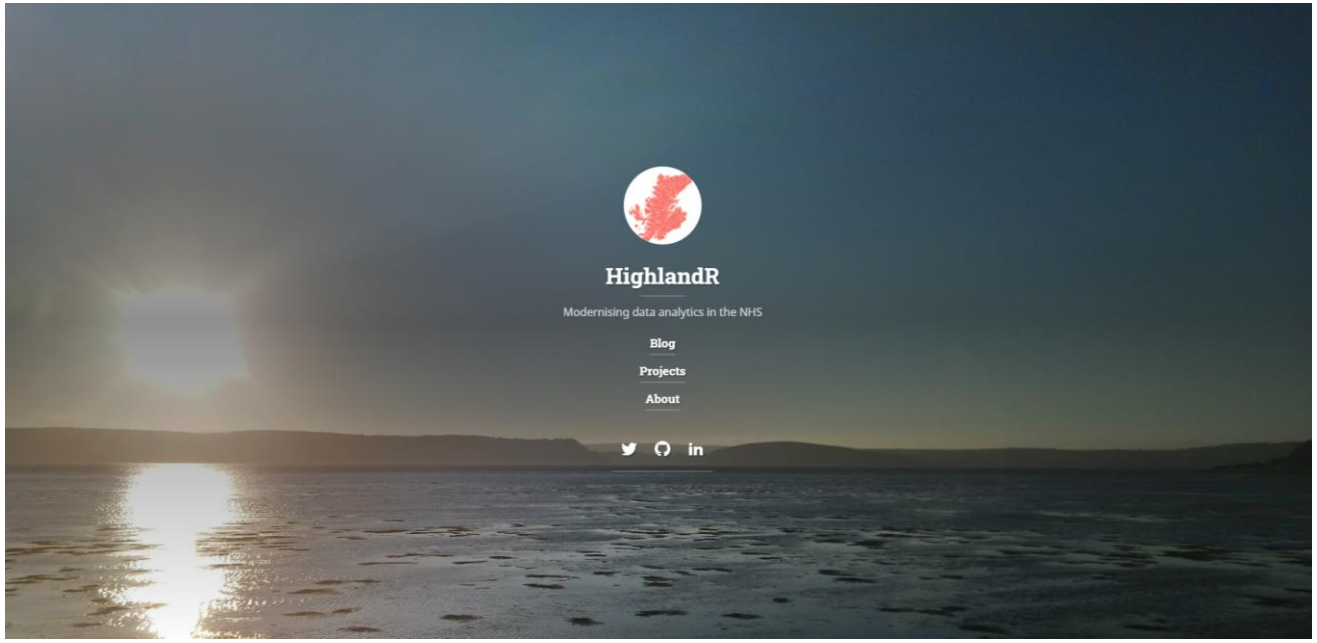
```
# spccharter
# single unquote group variable

by = group

# or 2 variables as character string
by = c('group','subgroup')


# runcharter
# only accepts one quoted group variable
# (for now)

grpvar = 'Ward'


# outputs

# spccharter

# plot only
outputs = 'plot'

# data only
outputs = 'data'

# a list with data and plot
outputs = 'both'

# runcharter
# returns a list containing data and plot
# currently no 'outputs' option to amend this
```

Main differences

Item	runcharter	spccharter
variables	quoted	unquoted (NSE)
grouping variable	1, quoted	1 unquoted or 2 as character vector
Y axis value	Supplied by user in desired format	Calculated from supplied numerator and denominator, with supplied number of decimal places
Outputs	Plot and data	Plot only, data only, plot + data

What’s next?

- runcharter : accept NSE and optional additional group variable
- spccharter : Prime P & U charts (for large denominators)
- Improve testing
- CRAN ?



https://johnmackintosh.net

@_johnmackintosh

johnmackintosh

https://www.linkedin.com/in/john-mackintosh-inv/

https://github.com/johnmackintosh/runcharter

https://github.com/johnmackintosh/spccharter