Evaluation of the Usability and Usefulness of Statistical Process Control (SPC) Charts in healthcare, a systematic review

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Introduction

Statistical Process Control (SPC), as a methodology, is useful in understanding variation and is applied to a wide variety of industries and systems. While there are many examples in the peer-reviewed literature of the application of SPC in understanding specific healthcare-related measures, there are fewer published reports of studies that have compared SPC to other, more frequently used analytical methodologies.

Background

This review was conducted to support a partnership project between the Social Care Division and the Quality Improvement Division to develop a Quality Profile in order to drive and evaluate quality improvement and inform strategy and decision making. The review provides the evidence base for the use of SPC charts by senior managers to identify opportunities for improvement as well as to identify successful quality improvement initiatives.

Key Findings

1. The number of eligible articles included in the study (n=19) was relatively low in comparison with the total number of articles that relate to the use of SPC methodology in healthcare (n=96). Although the use of SPC in healthcare continues to grow (Thor et al. (2007)), there remains a deficit in the literature of articles that demonstrate how SPC can be more effective than other methods of display of healthcare data.

2. The most common study design among the 19 articles included in the review were case studies. Only one randomised control trial was identified whereas five review articles were included in the final 19 articles reviewed. This is a reflection of the difficulty in designing studies that specifically address the research question.

3. The articles contained a number of case studies where SPC was compared to another method of displaying data. Details of a sample of case studies from six individual papers are summarised in Table 1. In all cases, the authors concluded that SPC methodology was not only appropriate in healthcare, but it provided a more useful understanding of healthcare data than alternative methods such as league tables, red-amber-green based charts or bar charts.

4. The review of Koetsier (2012) is valuable in highlighting differences in how SPC methodology is applied in the literature. These include differences in the rule set used to interpret SPC charts. In order to ensure consistency of application of SPC methodology in QI work, the Quality Improvement Division have adopted the rule set as described in the Health Care Data Guide (Provost and Murray, 2011). [Fig. 2: The 7 Steps to Effective Measurement for Improvement]

Measurement for Improvement Curriculum

This review has also helped to inform the Measurement for Improvement (MFI) Curriculum developed by the Quality Improvement Division. The curriculum describes the Context and 7 Steps to Effective Measurement for Improvement² and details the tasks, knowledge and skills that engaging in MFI work need to perform. Step five specifically relates to SPC methodology.

References


Guidance to Measurement for Improvement, available at nhseducation.nhs.uk

Fig. 1: 7 Steps to Effective Measurement for Improvement

- Is there an Opportunity to Improve?
- Choose Measures
- Plan Measurement
- Collect Data
- Analyse and Display Data
- Interpret and Present Data
- Evaluate Measures

Fig. 2: 7 Steps to Effective Measurement for Improvement

1²Adapted from the ‘Guide to Measurement for Improvement,’ available at nhseducation.nhs.uk

Table 1: 6 Examples of SPC Compared to Other Methods of Data Presentation

<table>
<thead>
<tr>
<th>Reference</th>
<th>Measure</th>
<th>Comparison of SPC charts with other methods of data presentation</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anhui et al (2016)</td>
<td>Count of number of adverse events in Mental Health services</td>
<td>Bar chart with target compared to an SPC Chart</td>
<td>The bar chart highlights three instances where the target is breached. However, the same data displayed on an SPC chart shows only normal variation.</td>
</tr>
<tr>
<td>Guthrie et al (2005)</td>
<td>% of Type II diabetes patients with HBA1c ≤ 7.4% in GP practices</td>
<td>League table with and without 95% Confidence Intervals compared to a Funnel Plot</td>
<td>The Funnel Plot shows that most of the variation is random and there are less signals for action than are observed using the league tables.</td>
</tr>
<tr>
<td>Marshall et al (2004)</td>
<td>30-Day mortality following admission for myocardial infarction at each of 28 acute care hospitals (case study 3)</td>
<td>Ranked histograms with 95% confidence intervals compared to an SPC chart</td>
<td>5.9% of acute care hospitals were ‘singled out’ for further investigation based on league tables compared to 0.7% using SPC charts (P&lt;0.002). Using the SPC chart, only one service provider showed unexpected variation on the SPC chart (showing a rate lower than the lower control limit).</td>
</tr>
<tr>
<td>Mohammed et al (2001)</td>
<td>Mortality rate in 9 neonatal units (Case Study 4)</td>
<td>League tables compared with an SPC chart</td>
<td>Parry et al (1998) concluded that league tables were unreliable as indicators of performance. Using the same data to generate an SPC chart, Mohammed et al demonstrated that only normal variation was observed.</td>
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<tr>
<td>Schmidek et al (2016a)</td>
<td>Number of unplanned admissions within 48 hours of discharge</td>
<td>Line graph (as provided in board papers) compared to an SPC chart</td>
<td>Only common cause variation was observed using the SPC chart to display these data. The line graph did not provide an understanding of whether the variation observed was expected or not.</td>
</tr>
<tr>
<td>Waller et al (2016)</td>
<td>% of Emergency Department patients that are seen within 4 hours</td>
<td>Paired comparison before and after an intervention using a column bar chart compared to an SPC chart</td>
<td>Using a bar chart to display a paired comparison before and after the introduction of an MAU, an increase in the % of ED patients seen within 4 hours was evident. An SPC chart based on the same data shows that this is an incorrect interpretation as the improvement was not sustained. Within three weeks, the % of ED patients seen within 4 hours had returned to levels consistent with those prior to the intervention.</td>
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</table>

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