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Using Statistical Process Control through the Making Data Count approach to visualise data in NHS Trusts: a mixed methods study

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BMJ REQUIREMENTS:

What is already known on this topic:

Statistical Process Control (SPC) charts are recognised as valuable tools for healthcare leadership teams, helping to distinguish signals (special cause variation) from natural fluctuations in data (common cause variation).

The Making Data Count (MDC) programme has been effective in promoting the use of SPC charts in National Health Service (NHS) Trusts in the UK.

What this study adds:

Semi-structured interviews of NHS Trust board members reveal they consider MDC and SPC as a useful intervention in their Trusts to monitor interventions, guide further investigation and highlight performance issues.

Trust board meeting observations showed 72% (n=71) of performance statements made in meetings were supported by a relevant SPC chart.

How this study might affect research, practice, or policy:

The findings reinforce the need for continued investment in SPC training programmes to enhance data literacy among healthcare leaders. Future research could explore how SPC use in Trusts influences patient outcomes, operational performance, and service delivery improvements.

Abstract:

Introduction: English NHS Trust Hospital board members are collectively responsible for ensuring high-quality care and organisational performance. Integrated Performance Reports (IPRs) support boards by tracking key performance indicators, supporting quality improvement and providing assurance to NHS England. Statistical Process Control (SPC) charts can support leaders to distinguish signals (special cause variation) from natural fluctuations in data (common cause variation). The Making Data Count (MDC) Programme has effectively increased the use of SPC methodology in NHS Trusts. This study explored board members' experiences of MDC and SPC, and SPC use in public board meetings.

Methods: Fourteen semi-structured interviews were conducted with executive directors and non-executive directors across five NHS Trusts. Thirteen board meetings were observed, and quantitative data was coded and extracted to evaluate if SPC outputs supported assurance and decision-making.

Results: Board members generally expressed positive views towards the MDC Programme and SPC, recognising their value as a supporting tool to monitor interventions, guide investigations, and highlight performance issues. Board members noted insufficient training, and instances of inappropriate use or overuse of SPC charts. The observations showed that of the 99 statements made by board members, 71 (72%, 95% CI 62%-88%) were supported by a relevant SPC chart. Unsupported or unverifiable claims made by executive directors were more likely to be statements of improvement (p=0.054). Six decisions were made for further investigative work, and all six were supported by an SPC chart.

Conclusions: Making Data Count SPC charts are seen as a helpful tool, and their outputs are used reasonably effectively in a board environment. However, consistent and repetitive

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training is necessary to optimise SPC use and prevent misuse or overuse. Training may only partially prevent misuse of SPC charts due to managers' tendency to try to demonstrate improvement to other staff members.

Introduction

Within English National Health Service (NHS) Trusts, hospital board members have a duty to maintain and improve the quality of care and are collectively accountable for their organisations' performance and strategic direction [1][2]. Boards consist of executive directors and non-executive directors, with the latter playing an important role in holding the former to account for organisational performance and delivery [3]. Integrated Performance Reports (IPR) support boards by tracking key performance indicators, enabling them to drive quality improvement and provide assurance to NHS England. Data presented to boards should be actionable and help board members identify both challenges and achievements, facilitating informed decision making [2] [4].

Data in IPRs has historically been presented in Red-Amber-Green (RAG) spotlight reports or non-control charts such as line or bar charts [5]. In the past decade, statistical techniques such as Statistical Process Control (SPC) charts have been widely adopted as a standard approach within IPRs. In 2017, a review of Trust board performance reports showed that only 6% of charts and 57% of board papers represented the role of chance in data fluctuations, e.g. with SPC charts [6]. In 2021, 85% of board reports who received dedicated SPC training contained a minimum of six SPC charts post-training, a significant increase from 28% before training [7].

SPC methodology is often used to manage change and improve healthcare processes [8] [9]. SPC charts seek to categorise processes into those exhibiting expected variation (common cause variation) and unusual variation (special cause variation). In the context of NHS Trust board reporting, SPC can monitor healthcare processes to ensure that operational performance and the quality of care are acceptable and not deteriorating [10]. SPC charts can strengthen statistically informed decision-making compared to non-control charts and thus help board members distinguish signals from noise [11]. Nonetheless, the suitability of control charts should be evaluated, and incorrect use could lead to misleading conclusions [12].

The Making Data Count (MDC) Programme is at the forefront of driving SPC adoption in the NHS. As of July 2025, the MDC delivery team has trained over 50,000 NHS staff and 164 Trust boards (out of 212) through a 90-minute board development session. MDC has online teaching resources and has developed SPC tools for organisations to deploy [13]. The programme addresses the primary barriers to SPC adoption: lack of training and awareness, lack of perceived benefits, and difficulties in the analysis and construction of control charts [8]. Research has demonstrated that the MDC training sessions are well received and beneficial to board members in highlighting the importance of chance and correct data visualisation to inform decision-making [7]. A retrospective evaluation showed that hospitals that received dedicated MDC training increased their SPC uptake nine-fold relative to controls [14]. Furthermore, a more recent randomised controlled trial showed that SPC charts increased in Trusts that received MDC training and control sites, suggesting a contamination effect, indicating the organic spread of SPC across hospitals in England [15].

MDC teaches SPC in a distinct way, adopting a unique colouring convention to highlight special cause variation, and icons that help summarise the variation type and assurance level (Figure 1). MDC emphasises how SPC can be deployed in a performance and

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assurance context; this contrasts with SPC being taught mostly as a method within improvement science.

Figure 1: An SPC chart without highlighted special cause variation vs. an SPC chart with highlighted special cause variation (MDC method) including the Making Data Count summary icons [13]

While SPC use has increased through board-level training [7][14], we do not know of any research that evaluates the application of SPC within NHS Trusts. The study aims to explore to what extent SPC methodology is used effectively as part of board performance reporting in Trusts that completed the Making Data Count board training intervention.

Methods

We have used the Standard for Reporting Qualitative Research (SRQR) to structure the methods [16].

Approach and research paradigm

This study is a convergent parallel-database design, in which two distinct strands of data were collected and analysed independently, before being brought together in the interpretation [17]. We conducted semi-structured interviews with hospital board members to gather their perspectives, and quantitative observations of whether Trust boards used SPC charts to support board members' statements and group decisions.

Data was collected solely by the lead author. The lead author was affiliated with the Making Data Count Team during data collection. The author had no personal relationships with any participants and no conflicts of interest with the involved Trusts.

Context

NHS Trusts in England include the acute, mental health, and ambulance sectors. NHS Boards are composed of executive directors and non-executive directors. They meet publicly, usually monthly or bi-monthly. Some Trusts videotape their meetings and make these available via their organisation's website or YouTube.

Sampling Strategy and units of study

Interviews

Using the method of Fugard and Potts [18], we established that a sample size of 14 to 19 interviews would be sufficient when seeking to find relevant themes occurring in 15% to 20% of the interviews. We therefore approached six NHS Trusts for support with the interviews, requesting 3-5 board members per organisation. The chosen Trusts had received MDC support, including at least one board development session. They were using MDC SPC charts extensively within their trust business intelligence reporting (checked via reviewing existing public board papers). This represents a purposive sampling approach of Trusts that received similar support [19]. Five organisations agreed to participate in the study. The Trusts were asked to identify volunteers and to include both executive and non-executive directors. No other inclusion or exclusion criteria were applied. By asking the Trusts to identify volunteers, it was hoped to minimise researcher selection bias. However, Trusts may have selected board members interested in data or MDC. The five Trusts covered acute, mental health and ambulance Trust types. 14 board members were identified for interview

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across the five NHS Trusts, including chief operating officers, chief digital officers, performance directors, chief finance directors, and non-executive directors.

Observations

We conducted 13 board meeting observations across 13 Trusts (three interview sites and ten additional sites). They were selected based on two criteria: evidence of MDC SPC usage, and availability of public board meeting recordings. As the meeting recording had to be publicly available online, two interview sites could not be observed. Meeting dates ranged from June 2023 to June 2024.

Ethical issues pertaining to human subjects

Approval was given for the study by the University College London (UCL) Institute of Health Informatics Research Ethics Committee on 31/01/2024, reference number 15-IHIREC. The NHS Trusts and participating staff data was anonymised by removing personal identifiers from interview transcriptions.

Data collection and data processing

Interviews

Interviews were conducted over three months, each lasting up to thirty minutes. The interview consisted of core questions and prompts for additional enquiry when necessary.

1. What are your general views on MDC and SPC?
2. Can you describe your experience with implementing MDC in decision-making processes?
3. How do you perceive the impact of SPC on the behaviours of board members during decision-making?
4. What challenges have you observed in integrating SPC into your work?
5. What could have been done to make the intervention more successful?

All interviews were held via MS Teams and were transcribed and anonymised in MS Word. Data was imported to NVivo for coding and analysis.

Observations

During observations, data was collected to assess whether SPC was understood and effectively used to provide assurance or inform decision-making. The observations only focussed on the public board meeting's IPR agenda item.

A proforma (Table 1, supplementary) was used to standardise data collection.

Data extraction - observations

Claims made by Trust board members were extracted from video recordings of the meetings. For each claim made, the relevant board paper was reviewed, and (where available) SPC information was extracted along with decisions based on an SPC chart and associated SPC data. The individual's role (executive or non-executive) was also recorded.

Data Coding - observations

Each claim was coded according to the type of performance described (performance improving, deteriorating, or no change). Claims were assessed to determine whether they were supported or not by SPC. For example, an improvement statement (e.g. key

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performance indicator X is better this month), was considered supported by the SPC chart if the chart showed improvement based on the type of statistical variation shown. Claims were deemed unverifiable if the relevant data was not present in the report or the data was presented in a non-SPC form. These codes were used to tally counts in table 1 (supplementary). The process was repeated across 13 board meetings, with overall counts aggregated. Similarly, decisions were assessed to determine whether they were supported by the relevant SPC chart.

Finally, when an unverifiable or unsupported claim was made by an executive director, any challenge from a non-executive director was noted.

Analysis

Thematic analysis foundations were used to analyse the interviews using an inductive approach [20]. NVivo was used for analysis.

Descriptive statistics were used to analyse the extent to which SPC charts were correctly used to inform discussions or decisions. Stata was used. Exact Poisson and binomial 95% confidence intervals were calculated for count and percentage data respectively. Fisher exact tests were used for significance testing.

Techniques to Enhance Trustworthiness

Interview questions were piloted with non-participating NHS staff. Qualitative coding of the first interview was done with the second author. The remainder were done just by the first author, with any uncertainties discussed with the second author.

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Results

Interviews

Seven interviewees were executive directors, and seven were non-executive directors. There were no observed differences in sentiment between non-executive directors and executive directors, or between organisations. Most interviewees were familiar with MDC and SPC. Three interviewees talked more generally about data in their organisation with limited reference to SPC or MDC, even when prompted. As a result, their comments did not significantly contribute to the presented themes.

Our qualitative findings are organized across two higher-level themes: 1) facilitators indicating effective SPC use (table 2, supplementary) (Themes A – I), and 2) challenges and factors inhibiting effective SPC use (table 3 supplementary) (Themes J – T).

Factors facilitating SPC adoption

MDC was thought to be a programme that adds value to board members' respective organisations (A). Interviewees thought the training delivery was engaging and helped teach board members SPC foundations (B). Interviewees praised the training and support offered, acknowledging the impact of the training on facilitating understanding of SPC performance reporting (B). Board members thought the MDC approach to visualise SPC provided a consistent way to visualise data and a common language that aided triangulation and data storytelling (C).

It was acknowledged that decision-making, particularly within NHS Trusts, is complex and multi-disciplinary. SPC was thought to support decision-making rather than be a decision-making tool. Themes were grouped into three sub-themes where SPC supported decision-making: it facilitates staff to identify the key areas of concern or success and escalate issues appropriately (D); it enables understanding of the impact of interventions; and it informs commissions of target investigations or deep dives (F). A key element of MDC's approach is using SPC in an assurance context. One interviewee summarised that most indicators used for assurance are suitable for SPC. Another felt that SPC helped hold themselves and the Board accountable by having the proper management discussions and is a tool that did not allow bluffing or number manipulation. One person, who works for two organisations, felt more assured in the organisation that used SPC (G).

Finally, while not raised in all interviews, some highlighted efficiency gains using SPC. One person said the most significant benefit they saw was the reduction in spuddling, a 17th-century word the MDC team used to denote unnecessary action because of trivial things, in other words overreacting to common cause variation (I, H).

Challenges and factors inhibiting SPC adoption

Many of the results above show that interviewees perceived the intervention as useful. Nonetheless, interviewees reflected on the importance of training and acknowledged that SPC was not always the most appropriate technique (J, R, S).

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The most common technical challenge was using SPC language, and the unique SPC icons MDC created to summarise SPC outputs. Interviewees thought technical terms like “special cause variation” were unintuitive and put people off. They thought the icons were not always helpful and not used by staff (P). Interviewees gave examples of where SPC was not the most appropriate data visualisation technique, for example, for visualising financial or project management data. One interviewee thought their Trust had overused SPC, and RAG provided a more accessible view. Interviewees also highlighted that SPC forces one to focus heavily on trends, which may lead to staff missing a key performance indicator that is failing a performance target (R, S).

The most common non-technical challenge was related to training and education. Interviewees were not always sure new starters received any SPC training and thought their Trust could do more to tackle this (J). Interviewees stated that middle managers only occasionally possess the required analytical competencies to excel in their roles, with some struggling to interpret SPC charts (K). Some board members took the initiative to ask their colleagues whether they had completed the required training. One board member thought an SPC test should be given to new managers in the NHS.

The physical production of SPCs came up in some conversations; opinions varied, but some staff thought it was time-consuming to produce the charts and required high-quality business intelligence teams (Q).

Interviewees wanted continuous development of their IPR with more precise and concise messaging and exception reporting at the forefront of the IPR process. A report full of SPCs was considered difficult to digest, citing lengthy reports containing too many metrics (M). The type of data presented in SPC was also emphasised; some thought viewing data at the organisational level often concealed divisional or speciality issues underneath this data (N). However, interviewees acknowledged it was more important that the organisation’s data governance was robust to unmask divisional or speciality performance (O).

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Observation results

Summary

Across the thirteen meetings observed, 127 statements were made stating improvement, deterioration or no change in a particular key performance indicator (summary results in Table 4, supplementary). The statements were made by 43 board members (31 executive directors and 12 non-executive directors). Of the statements made, 99 could be verified as being supported or unsupported by the relevant SPC chart in the report.

Of the 99 verifiable statements, 71 (72%, 95% CI: 62%-88%) were supported by the SPC output, and 28 (28%, 95% CI: 20%-38%) were not supported by the SPC output. Therefore, we can conclude that staff used SPC outputs to support their claims significantly more often than claims unsupported by SPC charts (Table 4, supplementary).

Decision making

There were six instances, across four boards, where a decision was made directly related to a key performance indicator presented in an SPC chart (Table 1). In each case, these decisions were deemed justified based on the type of variation seen. For example, one decision was made to commission further work to investigate cancer performance that showed a period of special cause concern. In another example, an executive director agreed to investigate and report back to a non-executive director who challenged why a measure consistently failed to meet the target driven by the SPC assurance output. Other decisions were made but were not counted as they did not directly relate to a performance indicator or SPC chart.

	Total
Decision supported by SPC chart	6
Decision not supported by SPC chart	0
Total	**6**

Table 1: Count of decisions made and whether they were supported by a relevant SPC chart

Comparing executive directors and non-executive directors

Executive directors and non-executive directors used SPC charts to support their comments with equal effectiveness. There was no significant difference in whether a statement made was supported or not supported by an SPC chart when comparing executive directors (70%, 95% CI: 58% - 79%) to non-executive directors (82%, 95% CI: 57% - 97%) (Table 4)

Table 5 (supplementary) summarises the 108 statements made by executive directors categorised by the type of claim made. 54% of supported claims (n=31) referred to a measure showing improvement. Whereas 80% (n=20) of the unsupported claims (n=25) also described an improving measure. Similarly, 83% (n=19) of the unverifiable claims (n=23) were associated with an improving Key Performance Indicator. These findings indicate executive directors showed an increased tendency to report improvement when SPC charts did not support their claims (Fisher exact p = 0.054). In all cases of unsupported or unverifiable claims, no challenges from non-executive directors were evident.

In contrast, in Table 6 (supplementary), of the supported statements made by non-executive directors (n=14), only 21% (n=3) were related to a measure of improvement. For unsupported statements (n=3), all were related to a measure getting worse; for those that could not be verified (n=5), 80% were also related to a measure getting worse. These results indicate a tendency for non-executive directors to focus more critically on negative performance trends.

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Discussion

Our study aimed to assess to what extent SPC is used effectively in board performance and assurance processes in NHS Trusts that completed the MDC. Interviews revealed that most board members were familiar with SPC and viewed the intervention to be broadly beneficial for NHS staff in the context of performance monitoring and decision-making. Board members identified both technical and non-technical barriers that inhibited use of SPC. These challenges warrant reflection and action from the MDC Team, relevant NHS Trusts, and NHS England. The board observations showed board members use SPC outputs to substantiate their claims more often than not. When SPC charts were not used to support claims, executive directors were more likely to claim performance improvements that were not evident in the relevant SPC charts. Finally, in only 4 of 13 Trusts, SPC was shown to directly influence a decision within a public board environment. However, no decisions were made that contradicted the insights provided by the relevant SPC chart.

Sustaining efficacy

Interviewees noted challenges, including a lack of understanding, overuse, and technical issues. While end users (managers) and SPC creators (analytical teams) may have received a single training session, targeted and repetitive training results in better learning outcomes [21]. Therefore, MDC should consider how repetitive and consistent training is provided to all staff, perhaps via mandatory training on an annual basis. Ensuring that the Making Data Count programme remains adequately funded is critical to embedding and continuously improving the application of Statistical Process Control across UK NHS Trusts.

However, training can only accomplish so much. Even if staff are sufficiently trained in SPC, they may still consciously or unconsciously make unsupported claims to promote their own agendas, which was evident in our observations.

Interestingly, non-executive directors never challenged executive directors when executive directors made unsupported claims, contrary to examples in a study that non-executive directors did often challenge what executive directors were saying [3]. The reasons for this needs to be explored further, however we speculate lack of confidence or low analytical competency among non-executive directors may be contributing factors. Additionally, observations that took place in a public environment may lead to different board dynamics, perhaps less challenging of each other [22].

Interviewees gave examples of where SPC was not the most appropriate data visualisation technique and was sometimes overused. Trusts need to consider the most appropriate visualisation when creating reports and not use SPC for the sake of it [12].

Study limitations

The study only involved a small percentage of NHS Trusts using SPC. As the interview sites were known to the MDC team, and previous good relationships had been established, these sites may have a more favourable view of SPC and MDC. The impact of cognitive bias, particularly through the focussing effect, must be considered, as it may have led to responses directed to certain aspects of experiences or overshadowed other relevant information [23]. In addition, with data collected solely by the lead author, there is a risk of researcher bias that may have influenced the interpretation and recording of findings.

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Conclusions

Positive sentiments from board members of NHS Trusts have demonstrated MDC SPC charts are seen as a helpful tool. The study shines a light into how they are used within a public board environment to support statements made within these meetings. However, consistent and repetitive training is necessary to optimise SPC use and prevent inappropriate use or misuse.

Conflicts of interest

NK was working for the MDC Team during the study period. All other authors have no completing interest to declare.

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ROLE = EXECUTIVE	**Claim of improvement**	**Claim of deterioration**	**Claim of no change**	**Total**
Claim supported by SPC chart				
Claim not supported by SPC chart				
Cannot verify				
Total				

Decision making	**Total**
Decision supported by SPC chart	
Decision not supported by SPC chart	
Total	

Table 1: Example of the Proforma used to collect data of the board observations

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Theme	ID	Sub Theme	Quotes
Making Data Count	A	Interviewees described MDC as having a positive influence on their organisation.	● “Having connected with the MDC team, I think it became more insightful in terms of why were really doing this and why data really counts.” (Interview 6) ● “It (Making Data Count) is one of the few NHS England programme offerings that I have found genuinely really useful, both personally and to my organisation.” (Interview 8) ● “It was really helpful to have the national team involved.” (Interview 3)
	B	Interviewees had positive sentiments towards the board training delivered by the MDC team.	● “The MDC team were instrumental in making sure the board received sessions to explain what SPC performance reporting is all about.” (Interview 6) ● “The training was great…the training we received at board was really good, really engaging, which can sometimes be challenging I think.” (Interview 9)
	C	Interviewees said the SPC MDC approach to visualise data helped to provide a consistent framework and a common language.	● “MDC methodology has enabled us to take everybody through that journey… to (understand) how does it relate to other data and how do we tell the story.” (Interview 1) ● "They (SPC & MDC) are very useful way of establishing a common language." (Interview 14) ● “very helpful to have a standard for how you present run chart data…not just formatting, but analytically, because it means that people get used to a common language.” (Interview 8) ● “For the first time in the history of this organisation, that data is starting to talk to itself, it’s starting to tell a story and that becomes very powerful. (Interview 13)
Decision Making		Interviewees outlined different areas where they see SPC as a decision-making enabler. These have been grouped into three main themes, outlined below.	
	D	A tool to focus people’s minds on the particular areas they	● "From a decision-making view, it's (SPC) pointing me in the right direction as to what I need to look at and what I don’t.” (Interview 10)

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		should be concerned about or to highlight or escalate issues.	● “I think it (SPC) helps you (to) triangulate data… it does focus people’s minds (Interview 11).” ● “It (SPC) now provides a real focus for the front sheet of our (IPR), which says these are the areas you need to be concerned about, and it will show us what those areas are based on what the SPC charts are telling us… so our ability to focus on things…is significantly enhanced to the way that it was (Interview 4).” ● “they (SPC) are telling us where we've got problems and highlighting the problems, they do that a lotter better than a RAG report, because it shows it the trend, you shows you were you should be as well…you can see that actually make a decision from it." (Interview 12) ● “I think what SPC does it gives us the upper and lower limits of what would be expected….I think the fact that SPC will flag whether somethings going in the right direction…SPC gives you more visibility as you can see within those boundaries, the data going up or down in a way that you can’t with a RAG chart." (Interview 9)
	E	To track interventions and understand whether improvements are occurring.	● "We use it (SPC) for decision making, but we use it a lot for assurance and being able to track…where we've made progress or not and that itself is a decision… we've embedded it into our quality improvement approach as a Trust…(and) that’s how you derive the decision making. So it helps you make earlier decisions on whether things are working or not….its allowed board to call specific things out, ask the right question…it helps (to) impact our decision making.” (Interview 14) ● “I think it (SPC) adds value in terms of data informing decision making and helps us to also monitor trends, whether things are going the wrong way, the right way or you’ve sustained (performance)...we are able to see where we need to refocus our resources…for example if you’ve got workforce challenges in one team and actually we can see another team has got more workforce resource than required, we’re able to quickly look and decide it will be safe to move to another team.” (Interview 6)
	F	To commission further work, to understand more	● “It (SPC) also pinpoints areas that warrant us to maybe a do a deep dive.” (Interview 6) ● "I'm not sure I see those charts as a decision-making tool. I see them as a tool that allows us to better understand what's going on and ask better

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		information about a particular problem or area.	questions, to reach appropriate conclusions more quickly. Often that's about deciding where we need to do something. I don't know how much it actually drives the ultimate decision we might make. You know it might tell us of 10 areas, which three we need to worry and interrogate more, and that might lead to some decisions about doing something. I don't think the SPC chart that MDC use shape a decision (Interview 8)."
Assurance	G	Interviewees thought that SPC helps hold themselves and their board to account.	● "It (SPC) allows us to have the right management discussion for assurance… what's been very helpful is having conversations around managing expectations". (Interview 14) ● "It makes my role at this Trust much better (…compared to my role within another Trust), it provides me more assurance that I'm doing the job I should be doing… I don't have the same security at another Trust I work at who don't use SPC". (Interview 4) ● The majority of things that we do from an assurance point of view does lend itself well to be an SPC chart… so you can very clearly see trends…being able to read through a report and immediately see what's highlighted, what's not highlighted, and what's failing assurance is really good". (Interview 14) ● "It's useful to hold people to account and us as a board to account…having the SPC charts tells the stories and I can't go and bluff or make up stories, it's there, it's visible, they're able to say this hasn't really moved for the last six months … It helps me hold the organisation from board to floor to account as well (Interview 6)." ● "It provides me with more assurance that I'm doing the job that I should be doing,…as a non-exec director, and being able to provide assurance to the board is so different where we've got SPC (compared) to the organisation that we haven't got (SPC)". (Interview 4) ● "We're now getting some really interesting discussions within the Trust…It has enabled a more unitary board conversation…we must have had the intelligence as a group to be able to do that, but we didn't have the tools to facilitate that conversation." (interview 1)
Efficiency	H	Interviewees talked favourably about being more efficient	● "The controls and statistical methodology enable you to basically ignore a whole lot of movements and focus on the movements that are relevant." (Interview 10)

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		when using SPC. With reduced time spuddling and a shorter IPR.	● "In most boards if not all, have a conversation about a change in apparent point-to-point data… but its good, because it saves me answering questions on why it's going from 76,1 to 76.3, so that's helpful…is the kind of spuddling." (Interview 2) ● “That’s enabled us to in our IPR, for example, we’ve gone from 145 pages to 28.” (interview 1) ● "You can look at it very quickly and get a picture of what's going on, and as a non-exec who's pretty time-poor, it's quite accessible." (Interview 9) ●

Table 2: facilitators indicating effective SPC use

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Challenges	Ref	Sub Theme	Quotes
Training and understanding	J	Importance of regular SPC training. Training for new starters was identified as paramount but not necessarily always in place.	● "I think maybe staff just don't understand it." (Interview 11) ● "You could come in as a leader in the NHS and out of fear or embarrassment or lack of knowledge, be forced to wing it." (Interview 2) ● "I'm not sure whether the training has been available for the new members of the board (Interview 4)."
	K	Analytical skills for managers were lacking and not always seen as a core competency.	● "I think the NHS can be light on people understand data and can analyse data and can present it in way audience that will make sense." (Interview 11) ● "It has managed to, for some reason, bamboozle some of our managers, who still just don't get it…. its opened my eyes to the level of analytical competency that some of our managers have….and therefore we need to be think about our workforce for the future." (Interview 14)
IPR	M	Importance of concise and exception-driven reports.	● "We need to summarise (the IPR) a lot more, rather than have 35 pages of SPC charts." (Interview 12) ● "Its (the IPR) got over 100 SPC charts in the IPR, can any human brain digest that and turn that into information? Almost certainly not." (Interview 2) ● "That's enabled us to in our IPR, for example, we've gone from 145 pages to 28." (Interview 1)
	N	Cascading SPC throughout the organisation was thought to be equally, if not more important than using it at the Board.	● "You can't just change it at board level and think you've done, it's a marathon not a sprint." (Interview 12) ● "It's about moving beyond the boardroom." (Interview 8)
	O	Interviewees contemplated what level or cut of data should be at the board, whether to include site or specialty-level data or not.	● "We have to be clear on the hierarchy of what are the things that the board should be cited on…so that tiering of data is very important." (Interview 14) ● "Assure yourself the data hierarchy down organisation unmasks site based or specialty based data." (Interview 2) ● "I guess what SPC doesn't service so well or at least not at the board level is understanding variation across sites." (Interview 9)

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		Some wanted more granular data. The need for good data governance was thought to be key.	
Technical challenges	P	The most common technical challenge was that interviewees did not feel that the icons or use of technical language was intuitive or easy to use.	● “For people that are new to SPC, there’s a lot of iconologies to remember.” (Interview 1) ● “The symbols are over complicated in terms of what it is actually showing.” (Interview 3) ● There’s some of the terminology that has not been widely adopted…where we talk about common cause and special cause.” (Interview 10) ● “they don’t use the little roundels…the terminology just turns people off.” (Interview 12)
	Q	Some interviewees thought the technical process of producing SPC was challenging.	● "The process of putting them together…was actually quite time-consuming" (Interview 8) ● "I can see how a less matured business intelligence team without the right talent in, it would have really struggled to get as far and as quick as we had to. There's only so much you could do with spreadsheets, and there's only so much you could do if you don't have a, you know, BI [business intelligence] platform and competent data scientists." (Interview 14)
Data visualisation	R	Interviewees acknowledged that SPC charts were not always the most appropriate type of visualisation. In addition, interviewees thought there was overuse of SPC over other visualisation methods.	● “Not all the visualisation should be SPC charts.” (Interview 14) ● “I think we might have overused it, where sometimes another analysis method is more appropriate.” (Interview 3) ● “Where we’re missing targets, we missed the point and focus on the improved trend, but we might be marks off the target, and SPC drives us to focus on the improved trend rather than the facts we’ve missed the target completely.” (Interview 3) ● “On the downside, I think boards are less likely to look at trend data now ((E.g. 2019/20 annual year performance compared to 2023/24 annual year.))” (Interview 2)

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	S	While RAG was seen as not useful across most interviews, some interviewees highlighted that it is useful in some circumstances.	● I think there is a place for RAG in some things…you can't just dismiss it totally." (Interview 12) ● "I know people try and move away from RAG but it is simple and you can look at a report and if there's loads of Reds you know this problem. If there's loads of greens you know you don't have to focus on it so much. And I know that's very simplified but in times where time is of the essence that that really does help focus the mind." (Interview 3)

Table 3: challenges inhibiting effective SPC use

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	Number of supported claims (95% Poisson CI)	Number of unsupported claims (95% Poisson CI)	Number of claims that could not be verified	% of all verifiable claims that were deemed to be supported by the relevant SPC chart (95% binomial CI)	% of all verifiable claims that were deemed to be unsupported by SPC (95% binomial CI)
All claims	71 (56 -90)	28 (19-42)	28	72%% (62%-88%)	28% (20%-38%)
Claims made by executives (EDs)	57 (43-74)	25 (16-37)	23	70%% (58%-79%)	30%% (30%-42%)
Claims made by non-executives (NEDs)	14 (8-24)	3 (1-9)	5	82% (57%-96%)	18%% (4%-43%)

Table 4: Summary results from board observations

	Improvement	Deterioration	Stable	Total
Supported	31 (54%)	18 (32%)	8 (14%)	57
Unsupported	20 (80%)	4 (16%)	1 (4%)	25
Not verifiable	19 (83%)	4 (17%)	0 (0%)	23
Total	70	26	9	105
Fisher's exact p = 0.054				

Table 5: Detailed results for EDs from board observations

	Improvement	Deterioration	Stable	Total

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Supported	3 (21%)	11 (79%)	0 (0%)	14
Unsupported	0 (0%)	3 (100.0%)	0 (0%)	3
Not verifiable	1 (20%)	4 (80.0%)	0 (0%)	5
Total	4	18	0	22
Fisher's exact p = 1				

Table 6: Detailed results for NEDs from board observations