Figure S1 : Fishbone Diagram

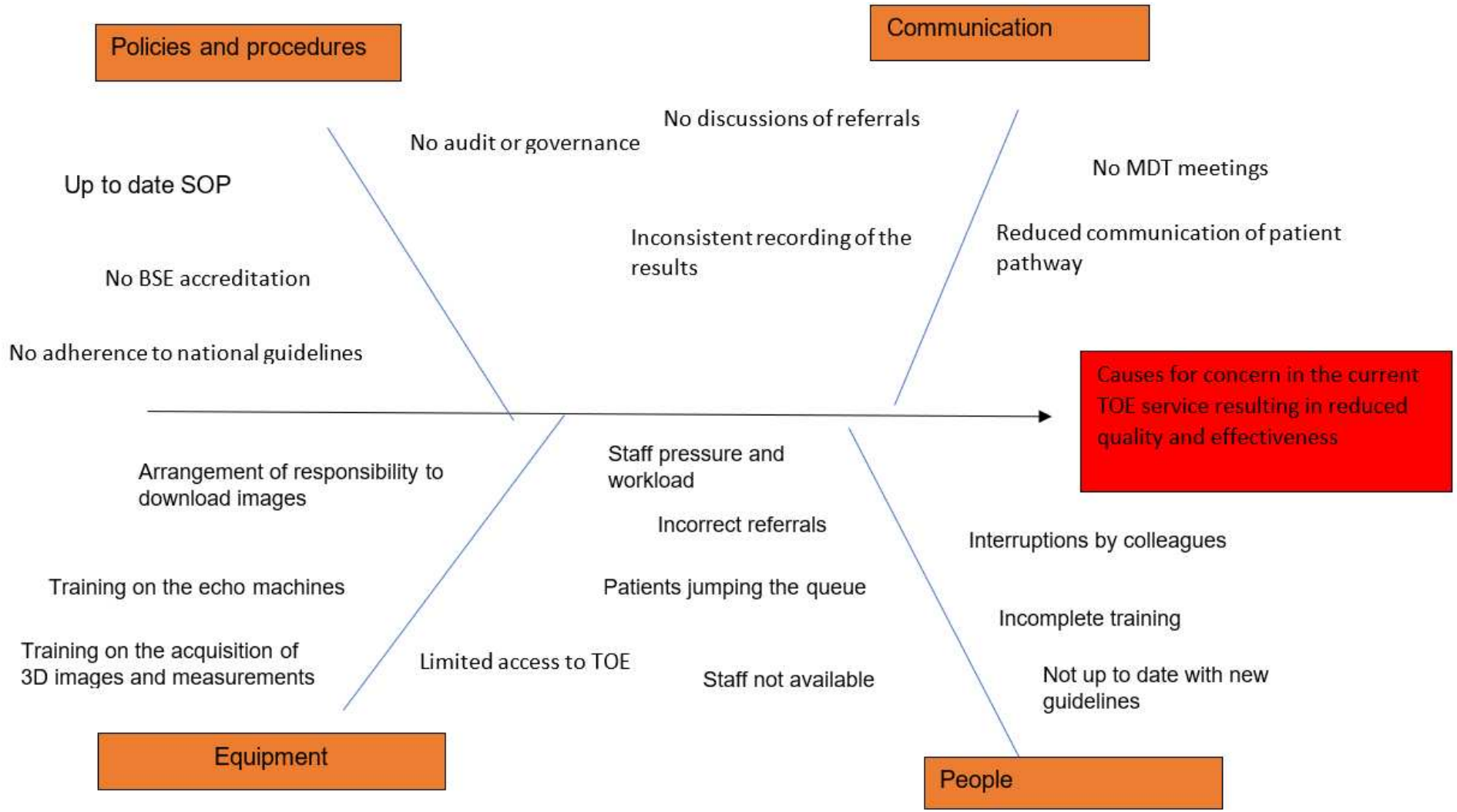


Figure S2 : 4N Chart demonstrating that staff were frustrated with the wasted time during a TOE and the increased patient waiting times (yellow = areas of focus for this QI project, IP = inpatient)

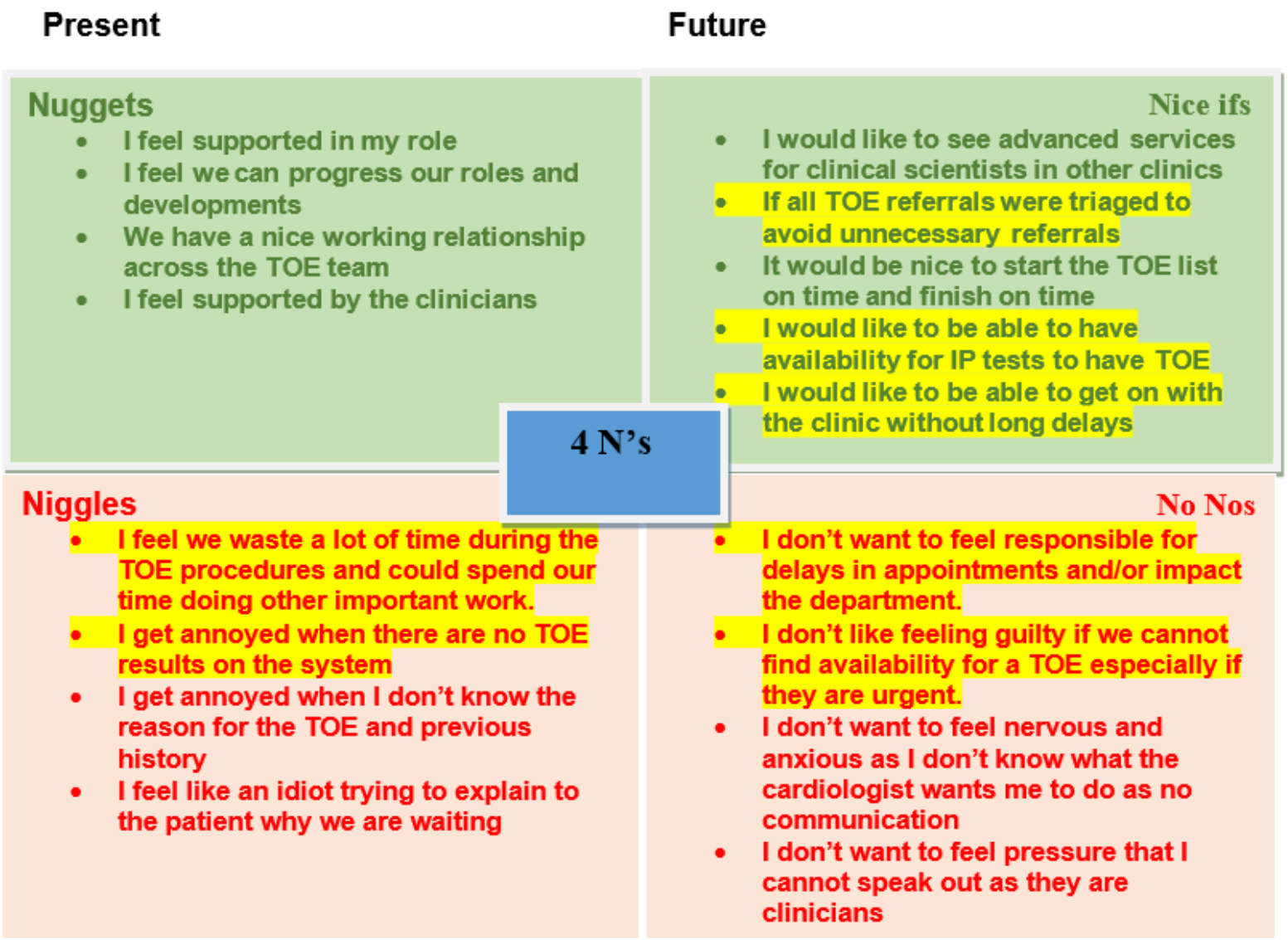


Figure S3: Driver Diagram

also locating the metrics (OM = outcome metric, PM = process metric, BSE = British Society of Echocardiography)

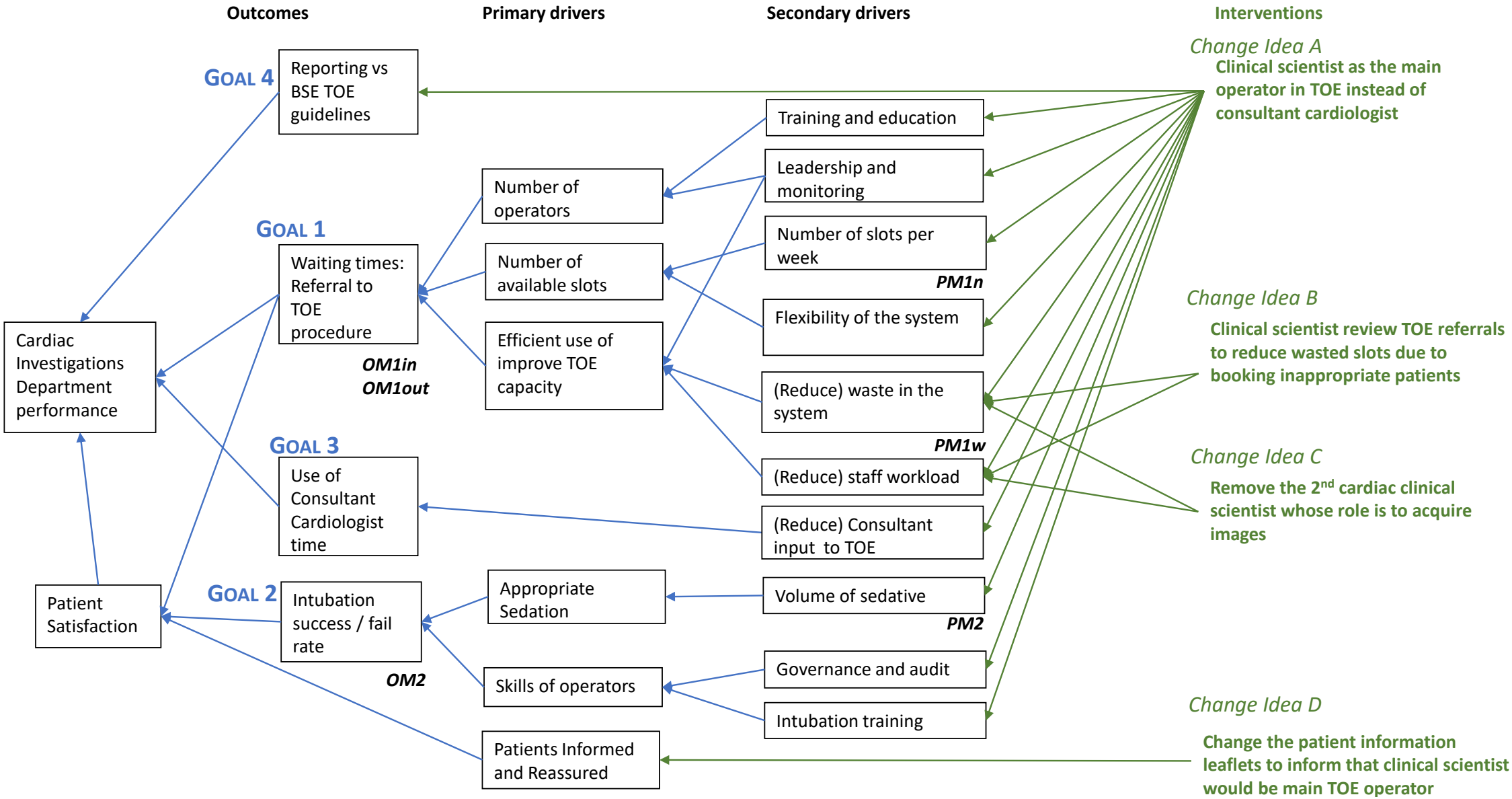


Table S1 : Niggle-o-gram for staff satisfaction: niggles experienced by staff members involved with the prior TOE service (yellow = agreed priorities)

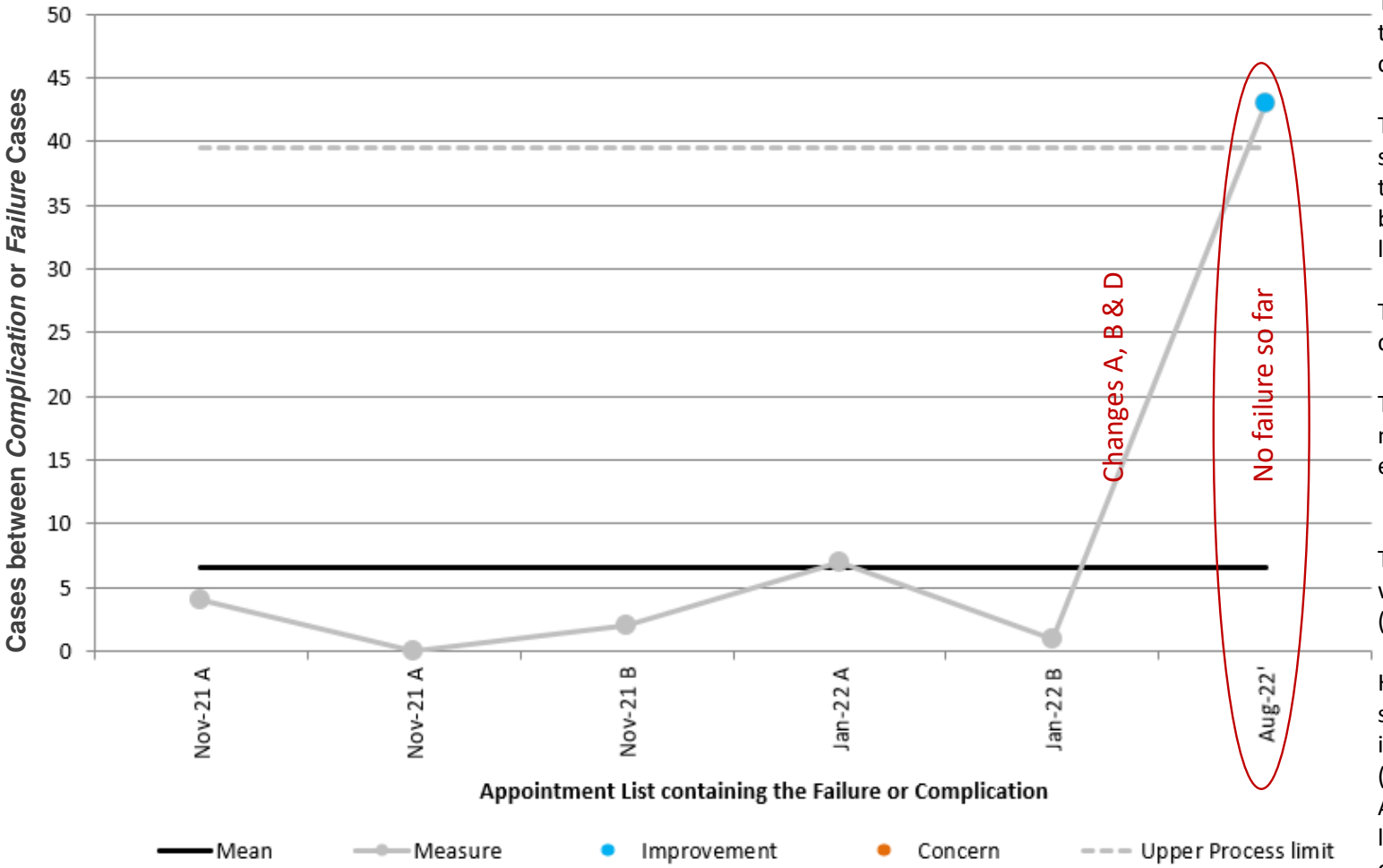
Niggle	Incidence (0-9)	Impact (0-9)	Influence (0-9)	Code (0-9)	Priority
Takes too long to perform a TOE with all the delays	8	9	9	8-9-9	3
Wasted time waiting for the cardiologist during the TOE	8	9	5	8-9-5	7
No communication between operator (cardiologist) and the clinical scientist and cardiac nurse.	7	7	4	7-7-4	8
No report on the system so when the patient comes back for a TTE, there is no results for guidance.	9	9	0	9-9-0	6
Trying to find slots and no flexibility on appointments	8	8	8	8-8-8	2
Long waiting times for a TOE which delays patients management	8	8	8	8-8-8	1
Limited progression in cardiac science	8	8	8	8-8-8	4
Limited training for progression	8	8	8	8-8-8	5

---------- Becomes irrelevant with change to be scientist-led (PDSA A) ----------

Table S2 Potential barriers to the QI project and proposed actions to overcome them

Potential barriers	Details	Proposed actions
Lack of support	- No support from the trust No governance approval No mentor for training	- Propose the benefits to the trust and governance Prepare a letter for governance Provide evidence of other organizations which have the process in place
Lack of understanding	- Other healthcare professionals Not a clinician performing the test	- Explain the needs of improving the services of advanced imaging to support the pressures and workload. More patients are undergoing valvular intervention who require advanced imaging prior to surgery.
Lack of staff engagement	- Lack of knowledge and understanding of the vision No involved in the process Don't want to be involved Don't want to progress	- Share the vision from the onset Embedding QI within the department Show how this will benefit the team
Staff shortages and workload	- Consultants' ability to provide support and training Clinical scientist shortage in main TTE to release them for advanced training Time for training and teaching	- Long term gain would be to reduce unnecessary referrals. Reduce number of TTE and go straight to TOE
Lack of training and education	- Lack of confidence in competence in ability Ensure enough numbers for competence	- Could be released to other trusts for the training Be involved with every consultant TOE list to improve confidence
Lack of supervision and leadership	- Clinicians maybe reluctant to relinquish advanced procedural skills, perhaps concerned about the consequences on their own individual practice.	- Propose the expansion of services which require multiple operators to reduce pressures Expanding roles will help deliver increased imaging demand
Lack of evidence	- Lack of evidence such as policy and procedure	- Demonstrate to the organization the need for the service and its success at other trusts. The cardiology workforce, GIRFT report and NHS Long term plan explain the need for advanced training in healthcare scientists.
Reduced opportunities for cardiology trainees	- Training clinical scientists may reduce training opportunities for cardiology doctors Although with time, clinical scientist will be involved in the training of medical juniors as well as other clinical scientists.	- Clinical scientist train cardiology trainees in TTE therefore could eventually train in TOE Consultant cardiologist lists could be training for cardiology trainees especially for the intubation.

Figure S4: SPC G-Chart of Cases between *Complication* or *Failure* Cases



The A and B are the first and second of the two lists per month (prior to the change to the scientist led service).

G-chart format SPC chart (see Provost and Murray, 2022, pp. 198-201 for technical details), using the NHS Excel template.

This format is designed for relatively rare events. Pre-change these were not very rare, but appear to have become so post-change.

The first 5 (grey) points are our complication or failure events shown on Fig 2. The metric is the number of cases between these events, so the first of our events in Fig 2 has censoring before it (the previous complication or failure event off to the left of Fig 2's PM2 graph so is not included here).

The last (**blue**) datapoint is the end of our data – with no complication or failure *so far.*

The horizontal line, the Centre Line (CL), is the 'theoretical median'. If *Gbar* is the mean of the number of cases between events, then:

$$\textit{theoretical median} = \ln(2) \times \textit{Gbar}$$

The template shows the SPC-style Upper Limit (UL) , which works out to be 39.46 cases, suggesting special cause (improvement) has been achieved.

However, we have very few data points so cannot establish a strong baseline. Nevertheless, any special cause is "a valid indication of a process with important special causes") (Provost and Murray, 2022, p.276).
Alternatively, we might ignore this process limit and treat it like an early stage run-chart analysis. Then, as with special cause on SPC, this last 'so far' data point might be considered 'astronomical' (Rule 4) even with these limited data "because it is a visual analysis not dependent on a median [and so] can be applied at any time based on the user's degree of belief" (*op. cit.* p.100).