


# Making Quality Registers Supporting Improvements: A Systematic Review of the Data Visualization in 5 Quality Registries

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## Abstract

Traditionally, quality registries have been initiated, developed and used by physicians essentially for research purposes. There is an unrealized opportunity to expand and strengthen the contribution of quality registries in healthcare quality improvement. This paper aims to characterize quality registry annual reports regarding factors deemed important to process improvement. The 2012 annual reports of the five most highly developed Swedish quality registries were examined. Each of the 636 charts included was coded according to an abstraction form. Results show that league tables are highly prevalent, whereas funnel plots and control charts are rare. Healthcare quality is monitored over time based on few and highly

aggregated measurements and it is usually measured using percentages. In conclusion, quality registry annual reports lack both the level of detail and the consideration of random variation necessary to being able to be systematically used in process improvement. Users of annual reports are recommended caution when discussing differences in quality, both over time and across healthcare providers, as they can be due to chance and insufficient guidance is provided on the reports in this regard. To better support process improvement, annual reports should thus be more detailed and give more consideration to random variation.

**Keywords:** Data visualization, healthcare quality registry, process improvement

## Introduction

Clinical quality registries are a particular subset of clinical registries, the purpose of which is to improve the safety or quality of healthcare provided to patients by collecting key clinical information from individual healthcare encounters which enable risk-adjusted outcomes to be used to drive quality improvement[1,2]. Thus, clinical quality registries comprise a wealth of standardized data regarding patient characteristics, clinical practices and outcomes and have been hailed as a *gold mine* in assuring and improving healthcare quality[3]. Traditionally, quality registries have been initiated, developed and used by physicians essentially for research purposes. Improvements in healthcare quality have thus been achieved by following a research approach, while these quality registries have only to a lesser extent been used for the purpose of process improvement. Consequently, there is an unrealized opportunity to expand and strengthen the contribution of quality registries in healthcare quality improvement. Annual reports are an important means by which quality registries can provide and should, therefore, be conceived to be supportive of process improvement. It remains, however, unknown whether annual reports fulfill this purpose and, if not, how their support of process improvement may be bolstered.

This paper aims to characterize the annual reports published by quality registries with respect to factors deemed important to process improvement. More generally, the paper aims at identifying opportunities for improvement in the annual reports of quality registries that can enhance their usefulness for process improvement without compromising their usefulness for research purposes.

**Theory**

Quality registries can complement randomized controlled trials, both by validating trial findings in groups that are often underrepresented and by identifying novel associations and generating hypotheses for future trials[4]. The registries can improve safety and reduce costs and there are several examples of quality improvements associated with registry data[5]. Quality registries should be used for high-cost, high-volume interventions for which there are variations in practice and where practice modifications can improve outcomes[6]. Concerning the quality of existing registries, it may vary greatly across quality registries[7]. Gitt et al. (2010)[4] warn that registry findings require caution since there is a high potential impact of unforeseeable confounders. Another peril lies in the early feedback on new techniques enabled by quality registries. Although they may be more effective in the long run, new techniques can be dismissed by virtue of their inferior short-term effects. The criticism against the public disclosure of performance data promoted by quality registries is particularly recurrent.

Porter and Teisberg (2007)[8] advocate that measuring results is essential for improving healthcare and that such measurements should focus on quality because improving quality would lower healthcare costs. Healthcare quality can be determined based on structural, process and outcome indicators[9]. Measurement and improvement are intertwined since it is impossible to make improvements without measurement[10]. Improvement, reporting and

research are three approaches by which improved quality can be achieved[11]. However, these approaches impose differing requirements on the collection and analysis of data and on the provision of feedback to stakeholders[12].

Understanding variation is one of the tenets of process improvement[13] and has its origins in the pioneering work of Shewhart (1931)[14]. If poorly understood, variation can give rise to a number of fallacies[12]. According to Berwick (1991)[15], controlling variation is often met with skepticism as it may be perceived by healthcare professionals as an attempt to restrict clinical autonomy and equalize medicine to industry. Furthermore, the *variation* concept means different things for different stakeholders. For clinical and healthcare researchers, the focus lies on testing causality by means of randomized controlled trials, whereas from the perspective of health managers, the focus lies on creating stable processes and learning from special causes by means of control charts[16]. The theory of variation control is explained by several authors[17-20] and emphasizes the need for monitoring processes over time, for instance by means of so-called run charts[21] or control charts[22]. Variation over time is sometimes called *diachronic variation*, whereas *synchronic variation* stands for the variation that exists across units at a specific point in time. Guthrie et al. (2005)[23] explain that the predilection for longitudinal data derives from the fact that they are statistically informed and rigorous, while simultaneously being pragmatic with a long history of use in other settings. To understand variation both location and spread measures should be used in describing observations. The possibility of using measures of spread depends on the measurement scale used[24]. Finally, the dichotomy between control and specification limits merits attention. Lloyd (2004)[12] discusses the differences between control and specification limits and explains that whereas the first term is associated with the intrinsic notions of stability and predictability, the latter is associated with the extrinsic notion of customer requirements. Control limits provide estimates of random variation, which is crucial when comparing the individual performance

of hospitals[25]. Besides random variation, observed differences in performance between hospitals are affected by patient characteristics, residual confounding, registration bias and quality of care[25].

## Method

### *Swedish quality registries*

Sweden occupies a prominent position in developing and using quality registries[26]. Annually, Swedish quality registries are evaluated and classified into one of the four following categories: *Candidate for National Quality Registry* (28 registries in 2013), *Level 3 National Quality Registry* (50 registries), *Level 2 National Quality Registry* (21 registries) and, finally, *Level 1 National Quality Registry* (6 registries) attributed to the most highly developed quality registries. The quality registries that in 2013 were awarded the *Level 1* status involved such diagnoses as prostate cancer, diabetes, acute myocardial infarction, stroke, hip replacement and HIV. The evaluation criteria (2012)[27] deal with such factors as registry organization and infrastructures, registry relevance and coverage, registry use in research, linkages to other databases and providing feedback. None of the variables examined in this study and mentioned below are explicitly addressed by any evaluation criteria. *Level 1 National Quality Registries* are nevertheless considered to be conducive of good to excellent conditions for systematic local process improvement and for providing feedback supportive of process improvement.

### *Sample and procedures*

This study has been focusing on the most highly developed quality registries, i.e. *Level 1 National Quality Registries*. Data were collected from the Swedish version of the annual report published by each of the quality registries selected. The six reports examined had been

produced by the *National Prostate Cancer Register* (2012) [PC][28], *National Diabetes Register* (2012) [D][29], *SWEDEHEART* (2012) [AMI][30], *Swedish Stroke Register* (2012) [S][31], *Swedish Hip Arthroplasty Register* (2012) [HP][32] and *InfCare HIV* (2012) [HIV][33]. All reports have been publicly available on the internet and referred to 2011, i.e. the 2012 publication year. For each chart contained in the reports, data had been collected using an abstraction form developed by the main author, who also collected the data. Textual information and tables were disregarded, as well as attachments to the reports. The abstraction form used in collecting the data was pre-tested with an *ad hoc* sample of charts. Thereafter, the abstraction form was revised and remained unchanged during the data collection phase. The variables included in the abstraction form, as well as the codes used, are shown in the table of results (Table 1). Data referring to *InfCare HIV*[33] were excluded from the analysis as the annual report only contained five ordinary charts, unlikely to add any value to the analysis.

*Scope and limitations*

This study has a number of delimitations. First, it focuses only on healthcare quality in Sweden. Second, among the multiple databases of healthcare quality[34,35], only quality registries have been included. Third, only the most highly ranked quality registries have been included on the assumption that opportunities for improvement identified in this study are equally, if not to a larger extent, applicable to lower level quality registries. The quality registries examined have consistently been among the best in Sweden over recent years, which permitted discarding eventual regression to the mean effects[36]. Fourth, quality registries contemplate feedback mechanisms to healthcare providers other than written reports. The ability of these other mechanisms to support process improvement efforts remains unknown. Nevertheless, to the knowledge of the authors, these mechanisms essentially consist of the possibility for healthcare providers to download raw data directly from the quality registry

database with no elucidative analyses or data visualizations being provided. Fifth, although the registries occasionally issue additional reports, e.g. the "10 Years Report 1995-2004"[37], this study focused on annual reports. The irregular or low publication frequency of such reports motivated their exclusion from the study. Furthermore, as the purpose was to provide a current description, only annual reports concerning patients and delivery of care during 2011 were examined. Finally, attachments, textual information and tables were disregarded from data collection for reasons of resource economy and based on the assumptions that the main information is displayed in charts and that charts are most effective in terms of triggering reactions by healthcare managers and practitioners.

*Quality of the data*

The quality of the documents can be assessed in terms of authenticity, credibility, representativeness and meaning[38]. Only the criterion of representativeness is relevant to the purpose of this study as the study focuses on the characteristics of the annual reports themselves, not on the quality of the evidence conveyed. Notwithstanding, considering the requirements imposed on *Level 1 National Quality Registries* the annual reports would score high on the authenticity, credibility and meaning criteria. *InfCare HIV* was the only annual report excluded from the analysis. As it represented less than 1% of the charts analyzed one can be confident that the findings are highly representative of *Level 1 National Quality Registries*. Highly pertinent is the issue of external validity, i.e. the generalizability of findings. As the requirements of the support provided by quality registries to process improvement are fairly similar for levels 1 and 2, results appear largely extensible to the annual reports of *Level 2 National Quality Registries*. Due to contextual similarities including the scarcity of resources available for process improvement, the prevailing mindset oriented towards clinical research, as well as the limited knowledge and experience of process

improvement, findings are expected to be generalizable to a large number of other healthcare quality written reports albeit to a more uncertain degree. As other report forms offer alternative possibilities, such as using animated visualizations that simultaneously display variations over time and place[39], one must exercise caution in generalizing the findings to healthcare quality reports other than written ones.

The research method employed, i.e. content analysis, sought to quantify the content of documents in terms of predefined categories and in a systematic and replicable manner[38,40]. This method usually yields the benefits of transparency and concomitant objectivity in data collection as well as potentially enabling the performance of longitudinal analyses. As the collection, analysis and presentation of registry data were expected to change slowly, longitudinal analyses were disregarded by the authors. The method also yielded the benefit of unobtrusiveness to the authors of the annual reports, which permitted ruling out the risks of reactivity bias. Although the data collection was labor-intensive, the use of publicly available annual reports constituted an inexpensive and quick means of collecting the data. A major disadvantage of content analysis is usually its inadequacy for answering why-type questions, something that was not the case in this study as it aimed at characterizing features of charts in annual reports. Another disadvantage deals with coder subjectivity and subsequent threats to internal reliability. The data were collected by the first author, which, on the one hand, enabled uniformity in data collection, but on the other hand increased the risks of researcher bias. To mitigate the risks of researcher bias, efforts were made to unambiguously define the codes used in the abstraction form. In order to promote intra-coder reliability, data collection occurred over a brief period.

## Results

In total, the annual reports contained 636 charts, of which 5 were excluded because they were repeated in the report or they were produced for other purposes, such as scientific papers. Table 1 shows that some charts displayed both synchronic and diachronic variation, whereas other charts displayed neither. The latter displayed often differences across age categories and sex. About 40% of the charts displayed synchronic variation. Diachronic variation was illustrated in nearly 45% of the charts. Table 1 also shows that percentages or proportions were used in about four of five charts. When examining only the charts that illustrated synchronic variation (table 2), one could find that healthcare units were ranked in 75% of the cases. Similarly frequent was the inclusion of internal comparators, such as national weighted averages. Fewer than one in four charts included mechanisms for distinguishing between special and common cause variation and assisting the reader to identify outliers. League tables accounted for 75% of the charts, whereas funnel plots were only used twice in total.

***Insert Table 1 and 2***

Table 3 provides a description of the charts that illustrated diachronic variation. Nearly half of the charts displayed between 3 and 10 time periods. Displays of two time periods were equally frequent as displays of time series longer than 10 time periods. The charts reported almost exclusively annual values although there were some cases of quarterly and biennial data. Time series, or run charts were prevalent and appeared in a variety forms, using lines, bars or disconnected dots.

***Insert Table 3***

**Discussion**

The results suggest that that much attention is dispensed to studying the evolution of quality indicators over time. Studying diachronic variation is an important approach to improving healthcare quality as it can result in the identification of outliers from which lessons can be drawn and improvements made[41]. The findings indicate however that the study of diachronic variation in annual reports is often limited to comparing current performance with last year's and that performance is reported almost exclusively on an annual basis. The provision of high-quality healthcare services requires delivering high-quality services every year, every month, every week and to every patient, something that cannot be assessed in the annual reports in their current form. Potential large variations over a year may pass unnoticed by monitoring events on a yearly basis. In other words, differences in quality may seem to be much less important than they actually are. Studying diachronic variation is also important to assess the results of quality improvement initiatives. The assessment of results requires timeliness, which is counteracted by the annual frequency of quality registry reports and the aggregation of data on an annual basis. From the perspective of process improvement, quality registry reports should be published more often and the results should be reported at a less-aggregated level. The provision of monthly or even weekly results would enhance timeliness and render within-year variation more obvious.

The importance of plotting results over time has been advocated by several authors, who have also stressed the necessity of giving proper consideration to random variation for instance by means of run charts or control charts[10]. Surprisingly, no control charts were found among the charts examined, although they are largely applicable to healthcare[42]. Alternatively to using control charts, data can be plotted on run charts and analyzed according to several rules. The numerous run charts included in the annual reports examined consist however of few measurements, typically between 3 and 10, which limits the possibilities of using several

such rules. Thus, not only are control limits missing, but also are run charts too *short* for being analyzed according to several run chart rules. This results in an increased risk for the user to miss indications in the data of potential problems as well as an increased risk for the user to react to *extreme* situations, the extremeness of which is due to chance.

Concerning synchronic variation, the comparison of healthcare providers is a long-established tradition in healthcare[43] and several reports give account of large variations in clinical practice among providers[44]. A reasonable proportion of the charts in the annual reports examined aims at comparing healthcare providers. Unreasonably however, league tables are largely prevalent despite the risks they pose of spurious ranking of healthcare providers[45,46]. This concern is aggravated by the infrequent provision of confidence limits or clear indication of outliers, as the findings show. Users of annual reports can thus engage in discussions about differences in quality between providers that are due merely to chance and should remain unaddressed. As well as some healthcare providers can be unduly identified as poor or good performers, some *de facto* outlying healthcare providers can pass unnoticed. Funnel plots are an alternative to league tables[47], which remains unexplored in the annual reports. Control charts are another alternative to league tables, as they can also be used for comparing the performance of healthcare providers at a specific point in time[48]. Nevertheless, no control charts were found among the charts examined. With respect to the use of comparators, most comparisons of healthcare providers in the annual reports examined included a national weighted average. According to Gliklich and Dreyer (2010)[2], the use of internal comparators, such as national weighted averages, is beneficial as it usually results in greater similarity in case mix between the healthcare providers compared and the comparator unit.

League tables, funnel plots and control charts can be used to compare healthcare units with respect to a single quality indicator. Nevertheless, quality reports contain data on several

quality indicators. In some reports, an overarching picture of quality across healthcare units is provided by means of the typical color scheme red-yellow-green. The selection of colors may be irrelevant but their meaning is not. Setting colors on healthcare unit performance by arbitrary definition of threshold ranks represents a misinterpretation of random variation[35]. The annual reports examined provided no examples of such misinterpretation. On the contrary, the three-color scheme used for comparing healthcare unit performance was defined with basis on the statistical significance of the difference between the healthcare unit and the national weighted average[29].

The argument of poor adjustment for differences in patient baseline characteristics is often adduced to justify a performance below expectations[49]. Indeed, poor adjustment may penalize healthcare units and providers that serve and care for riskier patients, such as minority patients, patients with low socioeconomic status or patients that are severely ill[50]. Risk-adjustment, as it is usually called, is thus critical but complicated[51,52]. This can put obstacles to quality improvement initiatives in general, and process improvement initiatives in particular. A potential remedial action deals with reporting change scores in performance besides absolute scores. The use of change scores in annual reports would yield the benefits of each healthcare unit being compared acting as its own control and of putting pressure in all healthcare units to improve over time. The current focus on identifying poor performers results arguably on efforts of poor performers to leave the conspicuous bottom of league tables and arrive to a comfortable land of nowhere among other average performers, far from public attention.

Findings showed a vast predominance of percentages and proportions in reporting healthcare quality, which, despite their ease of interpretation, pose some risks. Measuring quality as the proportion of patients treated within certain limits, e.g. percentage of patients whose treatment was initiated within 90 days after treatment decision, can result in

prioritization of patients whose waiting time is approaching the *magic threshold* of 90 days to the detriment of those patients whose waiting has already exceed the target time (The maximum waiting time guarantee in Sweden states among others that no patient should have to wait more than 90 days for an appointment with a specialist). As illustrated in[53], increased proportion of patients treated according to specifications can lack correspondence with improved mean value. Percentages provide moreover little information on the location and spread of the distribution of quality indicators. Furthermore, targets such as that described above are often arbitrary. Even when based on research, the targets concern patient groups that can differ significantly from the patient groups treated at the healthcare units for which the targets apply. To measure quality in terms of percentages enforces a counterproductive all-or-nothing perspective on quality, but it can still be acceptable when the quality characteristic is assessed according to several categories. The obstacles posed by using percentages in measuring quality can be surmounted by measuring quality on a continuous scale and examining both the location and spread of the distributions of quality indicators. The increased burden in data collection can be eliminated by focusing on measuring a few vital quality metrics rather than collecting a great deal of imprecise nice-to-have data.

**Conclusion**

League tables are highly prevalent in quality registry annual reports, whereas alternative data displays, such as funnel plots and control charts, are rare. In such reports, healthcare quality is monitored over time based on few and highly aggregated measurements. Moreover, healthcare quality is measured imprecisely by means of percentages. In conclusion, quality registry annual reports lack both the level of detail and the consideration of random variation necessary to being able to be systematically used in process improvement.

Users of annual reports are recommended caution when discussing differences in quality, both over time and across healthcare providers, as they can be due to chance and insufficient guidance is provided on the reports in this regard. Caution is also advised when discussing differences in quality measured using percentages. Quality reports should be published more frequently and report less-aggregated data. Moreover, quality reports should focus on absolute scores as well as on change scores of performance. Funnel plots and control charts should be used to a larger extent. It may be beneficial to collect more precise quality data on fewer variables.

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*Table 1 – Characteristics of data visualization in annual reports issued by quality registries*

| | ALL CHARTS | | | | | |
|---|---|---|---|---|---|---|
| Quality registry:<br>n=Nr. of charts included: | PC<br>n=85 | D<br>n=129 | AMI<br>n=253 | S<br>n=45 | HR<br>n=119 | Total<br>n=631 |
| TYPE OF VARIATION DISPLAYED (%) | | | | | | |
| Only synchronic | 53 | 15 | 35 | 51 | 6 | 29 |
| Only diachronic | 27 | 43 | 25 | 31 | 52 | 34 |
| Both | 0 | 27 | 13 | 0 | 5 | 11 |
| Neither | 20 | 16 | 28 | 18 | 37 | 26 |
| STATISTICS PLOTTED (%) | | | | | | |
| Counts | 1 | 4 | 8 | 4 | 20 | 9 |
| Percentages/ proportions | 91 | 61 | 82 | 93 | 77 | 78 |
| Average | 0 | 16 | 4 | 2 | 3 | 6 |
| Median | 8 | 0 | 4 | 0 | 0 | 3 |
| Other (e.g. individuals) | 0 | 19 | 2 | 0 | 0 | 4 |

*Table 2 – Characteristics of charts displaying synchronic variation*

| | SYNCHRONIC VARIATION CHARTS | | | | | |
|---|---|---|---|---|---|---|
| Quality registry:<br>n=Nr. of charts included: | PC<br>n=45 | D<br>n=54 | AMI<br>n=120 | S<br>n=23 | HR<br>n=13 | Total<br>n=255 |
| WITH RANKED PROVIDERS (%) | 96 | 50 | 81 | 78 | 54 | 75 |
| TYPE OF COMPARATOR (%) | | | | | | |
| Internal to the data | 93 | 83 | 55 | 78 | 85 | 71 |
| External to the data | 0 | 0 | 2 | 22 | 0 | 3 |
| CONSIDERATION OF CHANCE (%) | | | | | | |
| Outliers clearly indicated | 0 | 43 | 0 | 0 | 0 | 9 |
| Provision of confidence intervals | 0 | 26 | 6 | 17 | 46 | 12 |
| Provision of Interquartile ranges | 13 | 0 | 1 | 0 | 0 | 3 |
| TYPE OF CHART (%) | | | | | | |
| League table | 91 | 50 | 81 | 78 | 54 | 75 |
| Funnel plot | 0 | 0 | 2 | 0 | 0 | 1 |
| Other (e.g. maps, radar charts) | 9 | 50 | 18 | 22 | 46 | 25 |

*Table 3 – Characteristics of charts displaying diachronic variation*

| | DIACHRONIC VARIATION CHARTS | | | | | |
|---|---|---|---|---|---|---|
| Quality registry:<br>n=Nr. of charts included: | PC<br>n=23 | D<br>n=90 | AMI<br>n=94 | S<br>n=14 | HR<br>n=68 | Total<br>n=289 |
| NUMBER OF TIME PERIODS DISPLAYED (%) | | | | | | |
| Two | 0 | 17 | 31 | 0 | 38 | 24 |
| Between 3 to 10 | 61 | 82 | 27 | 50 | 43 | 52 |
| More than 10 | 39 | 1 | 43 | 50 | 19 | 24 |
| FREQUENCY OF CHARTING (%) | | | | | | |
| Shorter than one year | 0 | 0 | 3 | 0 | 0 | 1 |
| One year | 100 | 100 | 97 | 100 | 44 | 86 |
| Longer than one year | 0 | 0 | 0 | 0 | 56 | 13 |
| TYPE OF CHART (%) | | | | | | |
| Run chart | 100 | 59 | 67 | 100 | 56 | 66 |
| Other | 0 | 41 | 33 | 0 | 44 | 34 |