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Results of a multicentre randomised controlled trial of statistical process control charts and structured diagnostic tools to reduce ward-acquired meticillin-resistant *Staphylococcus aureus*: the CHART Project

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Summary Statistical process control (SPC) charts have previously been advocated for infection control quality improvement. To determine their effectiveness, a multicentre randomised controlled trial was undertaken to explore whether monthly SPC feedback from infection control nurses (ICNs) to healthcare workers of ward-acquired meticillin-resistant *Staphylococcus aureus* (WA-MRSA) colonisation or infection rates would produce any reductions in incidence. Seventy-five wards in 24 hospitals in the UK were randomised into three arms: (1) wards receiving SPC chart feedback; (2) wards receiving SPC chart feedback in conjunction with structured diagnostic tools; and (3) control wards receiving neither type of feedback. Twenty-five months of pre-intervention WA-MRSA data were compared with 24 months of post-intervention data. Statistically significant and sustained decreases in WA-MRSA rates were identified in all three arms ($P < 0.001$; $P = 0.015$; $P < 0.001$). The mean percentage reduction was 32.3% for wards receiving SPC feedback, 19.6% for wards receiving SPC

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and diagnostic feedback, and 23.1% for control wards, but with no significant difference between the control and intervention arms ($P = 0.23$). There were significantly more post-intervention 'out-of-control' episodes ($P = 0.021$) in the control arm (averages of 0.60, 0.28, and 0.28 for Control, SPC and SPC + Tools wards, respectively). Participants identified SPC charts as an effective communication tool and valuable for disseminating WA-MRSA data.

Introduction

Staphylococcus aureus is the single most important cause of hospital-associated bacteraemia.[1,2] MRSA infections are seen as symptomatic of a failing healthcare system and the incidence of MRSA bacteraemia rose significantly during the 1990s in addition to cases involving meticillin-susceptible strains.[3–7] Surveillance systems intended to reduce the incidence of WA-MRSA have had limited success.[8]

The Study on the Efficacy of Nosocomial Infection Control demonstrated that surveillance with feedback is an effective infection prevention and control (IPC) activity and resulted in the establishment of local and national surveillance programmes.[9–11] Some investigators have suggested that the quality of IPC practices can be improved by feeding back surveillance data to those involved in front-line patient care.[12,13] Statistical process control (SPC) charts have been strongly recommended for this purpose.[14–18] By analysing data over time, control charts can usually identify rate changes faster than if aggregated into larger samples and, additionally, can distinguish between two important types of variability.[19] For processes with stable incidence rates (termed 'in statistical control') data vary in a consistent manner around the mean (centre line or CL), i.e. 'natural variation'. For processes with unstable incidence rates ('out of statistical control') data vary in an inconsistent manner, i.e. 'unnatural variation'. Unnatural variation indicates either the introduction of more communicable MRSA strains or deterioration in IPC practices.

To determine which type of variation exists, control charts plot monthly WA-MRSA data along with the CL and lower and upper control limits (LCL and UCL) that define the range of natural variation, assuming that causal processes remain unchanged. These limits are typically set at three standard deviations above and below the mean, with early warning limits sometimes set at two standard deviations from the CL.[15]

In a previous study in one Glasgow hospital a 50% reduction in WA-MRSA incidence occurred after the introduction of SPC feedback.[20] The infection control team (ICT) produced SPC charts to provide awareness of each ward's natural and unnatural variation. These charts were found to be easy to produce, easy to produce feedback and helpful for communication and identification of infection control problems, providing a statistical rather than a subjective approach to identifying significant improvement or deterioration.

Once a problem is identified, quality improvement diagnostic tools such as Pareto and cause-and-effect charts may help to identify solutions. Fishbone cause-and-effect charts were developed to minimise transmission based on national MRSA guidelines and other publications that identify factors contributing to rate increases.[21,22] Other investigators have also suggested that feedback of audits in the form of Pareto charts, which are based on the principle that typically the majority of problems are attributable to a minority of causes, can help practitioners focus their remedial actions.[23]

The CHART study was undertaken to determine whether: (1) providing feedback in the form of SPC charts of WA-MRSA data to healthcare workers (HCWs) directly involved in patient care results in incidence reductions, suggesting improvement in infection control practices; and (2) additional use of cause-and-effect and Pareto charts as structured diagnostic tools promotes greater IPC improvements and incidence reductions.

The research described here is the main component of a multiple-method study that includes a descriptive component undertaken concurrently. It is the authors' intention that the descriptive component of the study will be the subject of future publications. In the interim a detailed account of the study is available to interested readers in the form of a full report made to the Department of Health from Dr P. Harper at the Richard Wells Research Centre.