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Adaptive EWMA and CUSUM Control Charts for Monitoring Disease Prevalence in Meta-Analytic Studies

Monitoring disease prevalence over time is critical for timely public health response and evidence-based decision-making. In many cases, prevalence estimates are obtained from a sequence of independent studies with varying sample sizes, as commonly encountered in systematic reviews and meta-analyses. Traditional control charts such as the EWMA and CUSUM have been widely used in industrial settings for quality monitoring, but their application to binomial proportions with variable sample sizes remains underexplored.

This work presents an adaptation of the EWMA and CUSUM control charts specifically designed for monitoring proportions (prevalence) in the context of meta-analytic data. The proposed framework dynamically adjusts the control limits based on the sample size of each study, ensuring correct estimation of variability and improving detection power. We derive formulas for control limits under both in-control and out-of-control conditions, and evaluate performance through the Average Run Length (ARL) metrics.

Using both simulated and real-world data on disease prevalence, we demonstrate that the proposed methods can detect both abrupt and gradual changes in prevalence trends. The charts are further shown to be effective tools for identifying outlier studies, shifts due to policy interventions, or emerging epidemiological patterns.

These techniques offer a novel approach for applying industrial statistical methods to public health surveillance and can be extended to other domains where proportions with variable precision are monitored over time.

Special/ Invited session

Classification

Both methodology and application

Keywords

prevalence, meta-analysis, statistical process control

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