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MCH

Research to Practice

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A Newsletter Dedicated to Promoting the Application of Findings from MCHB-Supported Research to Practice

Introduction to the Second Issue

The ability to (1) monitor changes over time in the occurrence and geographic clustering of rare perinatal events (e.g., infant mortality or morbidity) at the small subdivision level, (2) ascertain whether such changes are chance occurrences, and (3) identify the factors driving the changes is an ideal most maternal and child health (MCH) administrators wish they could attain. Translating this ideal into reality is difficult, but it is not impossible, as suggested by the findings from the research and development project supported by the Maternal and Child Health Bureau (MCHB), Health Resources and Services Administration (HRSA), and reported on in this issue of *MCH Research to Practice*. With some success, the project sought to adapt industrial quality-assurance (QA) methods for monitoring rare perinatal events in small areas such as counties, cities, communities, or census blocks or tracts. "We still have a long way to

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Development of Monitoring Methods for Perinatal Outcomes

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Statement of the Problem

Monitoring rare health events (e.g., adverse perinatal outcomes) in small geographic areas such as counties, cities, communities, or census blocks or tracts is a challenge for program planners and researchers. Currently there are no adequate methods available for monitoring short-term changes in rare perinatal events (e.g., infant mortality and morbidity) in small areas. Changes in the occurrence rates of these rare events are difficult to distinguish from random fluctuations over time.

Research Objectives

This project has two main objectives. The first is to assess the usefulness of industrial quality-assurance (QA) techniques (which were developed to monitor assembly-line processes and to detect defective or nonconforming products) in monitoring short-term changes in perinatal outcomes in small areas. The second is to assess the usefulness of

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go," the principal investigator (PI) of the project said during a recent MCH Research Roundtable Seminar, where she reported on project findings. The statistical content expert who reacted to the PI's presentation echoed her remark.

Nevertheless, a good start has been made. We hope that the research findings and the critique of those findings presented here will generate interest at the state and city levels in adapting industrial QA methods to the monitoring of rare public health events. Developing monitoring methods for use at the state and city levels is a declared MCHB research priority for 2000 through 2003. For those with an appropriate project and sufficient technical expertise to navigate the grant-application process, funds are available under the Special Projects of Regional and National Significance (SPRANS) research program category. States, cities, and institutions of higher learning can jointly produce an appropriate grant proposal and pool the experience needed to be selected for funding. Brokerage services to develop joint ventures are available from MCHB's extramural research program. Interested parties are invited to contact Gontran Lamberty, Dr.P.H., Chief, Research Branch, MCHB, at (301) 443-0765 or at glamberty@hrsa.gov. MCHB's new research guidelines are available from the HRSA Grants Application Center (CFDA#93.110RS), 1815 North Fort Myer Drive, Suite 300, Arlington, VA; telephone: (877) 477-2123; e-mail: hrsagac@hrsa.gov. The material can be viewed at and downloaded from the MCHB Web site: http://www.mchb.hrsa.gov.

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spatial stochastic-process techniques (which are used to study the relative presence of a health outcome and its spatially global and local variability) as a means for monitoring perinatal outcomes.

Study Design and Methods

To achieve our first objective, we used a modified cumulative summary QA method (CUSUM) to monitor short-term changes in rare perinatal outcomes, and the Average Run Length (ARL) to detect longer trends. Both CUSUM and ARL are well-established industrial monitoring methods. Using computerized birth certificates, we examined the following outcomes: smoking during pregnancy, initiation of prenatal care (PNC), very low birthweight (VLBW), low birthweight (LBW), and neonatal and postnatal infant deaths. We then produced a set of computer programs that can be used to create CUSUM charts for monitoring any type of health data.

To achieve our second objective, we used composite likelihood estimation procedures methods to assess the global and local spatial variability of four perinatal outcomes: VLBW, LBW, all infant deaths and infant deaths due to sudden infant death syndrome, and perinatal infections. Global variability measures the extent to which outcomes have similar values over the whole region of interest (e.g., the City of Baltimore), whereas local variability or clustering describes how correlated outcomes are across smaller neighboring areas. We used the regression method to explain the global and local variability of these outcomes with a set of social and behavioral covariates. This method yielded information on (1) the global and local spatial distribution of outcomes, (2) factors with intervention potential that are most closely linked to the local spatial variability of outcomes, and (3) factors most likely to reduce adverse outcomes to the greatest extent.

Major Findings

As a monitoring method, CUSUM was applied to data simulated from the perinatal outcome data derived from the City of Baltimore. By taking known rates, simulating outcomes from these known rates, and applying the CUSUM method to each simulation, one can determine how often the method is likely to detect true significant differences. Results showed that CUSUM is very effective at detecting short-term changes (either increases or decreases) in outcomes. CUSUM also performed well in settings where the events being studied occur infrequently. Even for smaller areas, CUSUM was able to detect rate changes that other means of detecting trends, and visual inspection of the data, failed to yield.

Spatial analyses found the average month of PNC initiation to be an important explanatory variable for global variability in birthweight and infant death outcomes. These analyses also suggest that factors explaining local variability, such as month of PNC initiation, are good bases for community-based public health interventions, because improved outcomes in these areas within an intervention community are likely to result in improved outcomes in immediately surrounding areas as well.

Conclusions

Using CUSUM and ARL methods to monitor rare health outcomes in small areas has several advantages. Such tools are fairly easy to use, as they require relatively few data and computing resources. Results are not difficult to interpret. Public health professionals with little or no advanced statistical expertise can implement these methods using common software packages (e.g., SPSS, SAS). The methods can also be used to help evaluate community-based interventions. Such interventions could be made more effective if the outcomes they targeted were evaluated before the intervention began or while it was in progress. For example, in the case of Healthy Start infant-mortality prevention programs, if perinatal outcomes had been monitored while the program was in its implementation period, program planners would have had information about how interventions were affecting target outcomes before the period ended, and they might have been able to use this information to enhance the program's effectiveness.

Results of the spatial analyses indicate that the average month of PNC initiation "explains" much of the local variability in birthweight and infant death outcomes, and that intervening on this variable can improve these adverse outcomes. The average month of PNC initiation may serve as a proxy for other factors more closely related to high rates of adverse outcomes. The average month of PNC initiation has been correlated with a host of other high-risk covariates such as low socioeconomic status, adverse living environments, and poor health behaviors.

This study has some limitations. First, the number of outcomes was limited because of the sample size. Second, the models assume that rates do not change substantially during the study period. While this is true for many of the outcomes, using the study's models to look at infant death data over longer

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periods of time would have been problematic.

Recommendations

Monitoring perinatal outcomes in small areas is feasible and should be useful for targeting interventions. QA methods could be used to identify changing outcome rates and could possibly deploy and focus interventions as appropriate. Spatial monitoring methods could be used to identify factors that are associated with local variability in outcomes and that would serve as good intervention candidates. ▲

Publications

O'Campo P, Guyer B. 1999. Innovative methods for monitoring perinatal health outcomes in cities in smaller geographic areas. *American Journal of Public Health* 89(11):1667–1672.

O'Campo P, Hedden M, Lele S. 1999. Monitoring the spatial distribution of perinatal outcomes: Maximizing the impact of public health interventions. Manuscript in preparation.

O'Campo P. 1996. Innovative methods for monitoring rare public health outcomes. Noon seminar for the Baltimore Department of Maternal and Child Health.

O'Campo P, Ju X. 1995. Monitoring methods for use in surveillance and monitoring of perinatal outcomes. Paper presented at the annual meeting of the American Statistical Association, Orlando, FL.

Response to Findings from the Perinatal Outcomes Monitoring Methods Study

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Tulane University

Dr. O'Campo's study presents two excellent approaches to the analysis of perinatal outcomes. The first approach identifies a set of practical tools that public health professionals can use to help determine whether the perinatal outcomes of the populations they serve have changed. The second applies methods that relate personal and neighborhood characteristics to changes in perinatal outcomes. Both approaches will be useful for the maternal and child health field.

Dr. O'Campo has proposed using a well-established method, CUSUM, to monitor perinatal outcomes in small geographic areas (e.g., counties, cities, communities, census blocks or tracts). CUSUM has been used to evaluate the quality of industrial output and practice since the mid-1960s. The method detects short-term changes (either increases or decreases) in outcomes. It performs admirably, even when the events being monitored occur relatively rarely. Dr. O'Campo suggests that Average Run Length (ARL) be used to detect longer trends. In addition to being more effective at evaluating such trends, the latter method also permits the identification of high-risk areas when it is applied to small segments of a large area.

The statistical properties of the two methods are well known. CUSUM can monitor count data even when the denominators for the monitoring period are not uniform over time. Poisson CUSUM can be performed for rare-event outcomes. CUSUM results are easy to calculate. Weighted averages of baseline rates can be adjusted to detect short-term acute changes or long-term slower changes.

To evaluate CUSUM's usefulness, Dr. O'Campo applied it to data simulated from perinatal outcome data derived from the City of

Baltimore. By taking known rates, simulating outcomes from these known rates, and applying CUSUM to each simulation, one can determine how often the method is likely to detect true significant differences.

For the city as a whole, the rate of late or no prenatal care (PNC) ranged from 3 percent to 9 percent. Of five changes of more than 1 percent, CUSUM identified two for 85 percent or more of the simulations, and ARL identified three for 85 percent or more of the simulations.

For the city's high-risk areas, the rate of late or no PNC ranged from 3 percent to 19 percent. Of five significant changes of more than 1.5 percent, CUSUM and ARL each identified four for 75 percent or more of the simulations.

It is important to note that the two methods did not identify all the significant changes. This suggests that care must be taken to select the weighting and decide which indicator to use.

CUSUM and ARL performed rather poorly in identifying significant changes in low birthweight (LBW) and very low birthweight (VLBW), both in the city as a whole and in the high-risk areas. This may be because these outcomes changed so little. Declines in infant mortality rates were detectable primarily with ARL.

Significant change must be evaluated in terms of the indicator used, and over a specified period of time. To do this will require thought on the part of the investigators. Questions that need to be asked include the following: (1) How large must a significant difference be before a study is conducted to identify the reason behind the trend or increase/decline in the outcome measure? (2) Is the difference the result of chance, or is there an explanation for it? (3) To what lengths should investigators go to determine which factors are responsible for the trend? (4) Once investigators start to monitor outcomes, can they ignore the trends and assume that they are the result of chance occurrences?

When studying trends in real time, investigators must remember that there is always next year to correct any current trends. Investigators must consider the costs involved in detecting trends, including those that are due to chance; they must also realize that they may fail to detect them.

To explain variability in outcomes, Dr. O'Campo used information on the outcomes over time in small areas together with variables derived from the small areas. To determine which of a set of social and behavioral covariates best explained the variability in four perinatal outcomes (VLBW, LBW, all infant deaths, and infant deaths due to SIDS and perinatal infections), she proposed the use of composite likelihood (CL) estimation procedures. The CL methods proposed assess the variability in outcomes among geographic units and provide estimates of global variability (census tract to census tract over the region) and estimates of clustering (extent to which neighboring census tracts are correlated) among the geographic units. Additionally, the covariates at the individual and group level can be added to explain the variability in the outcomes. These covariates suggest the means by which declines in poor prognostic indicators might be achieved. These methods are relatively new and have been adapted for use in geographic information system examples.

Dr. O'Campo compared the CL coefficients with those of the general linear model (GLM) and found them to be similar. She illustrated the use of the estimates of variability, both global and cluster, and the use of stepwise choice of covariates. Finally, she demonstrated the usefulness of the final model in the prediction of the number of VLBW infants born when the average month in which PNC began was reduced from month 3 to month 1.

For CL methods to succeed, confidence intervals for the estimates and the prediction must be established. The following questions should be asked: (1) How much variability is explained by these variables? (2) Are there any goodness of fit measures? (3) How good is the prediction? (4) In the GLM the variability decreases nicely as explanatory variables are added. In the CL method additional variables may increase the global variability or cluster. How can this phenomenon be explained? (5) All the variables are summary measures at the census tract level. Does this model have the same problems as other ecological analyses? In the demonstration of the method, the time dimension was eliminated. It will be important that future studies incorporate time trends.

The model does not use race as a variable. Race is correlated with rate of unemployment, adolescent births, and the average month in which PNC began. Could the variables identified be surrogates for race, a factor we cannot intervene on?

In summary, CUSUM and ARL are useful to investigators for monitoring trends in perinatal outcomes in small areas. They are also helpful to those interested in getting to know their neighborhoods for community-education interventions. However, follow-up is needed to determine whether programmatic efforts made as a result of investigations are successful at changing outcomes.

CL methods need to be more fully developed and interpretation issues more clearly defined. It is important to recognize that variables identified by this method are associated, but are not necessarily causal in explaining variability. The method should be viewed as hypothesis-generating rather than as proof of causality. It should not replace solid research that evaluates the interventions suggested by the variables. ▲

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