Active Surveillance of Maternal Mortality in New York City

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Objectives. This study examined the usefulness of computer-assisted active surveillance in identifying maternal deaths in New York City.

Methods. Computerized searches of hospital discharge and autopsy record databases were conducted for maternal deaths occurring in 1997.

Results. Active surveillance revealed 14 new maternal deaths not previously reported, an 88% increase. Nine of these deaths were found through the hospital discharge database search, 1 was found through the autopsy record search, and 4 were found in both searches. Overall maternal mortality ratios associated with active surveillance and routine surveillance were 24.3 and 13.0 deaths per 100 000 live births, respectively.

Conclusions. Active surveillance of maternal mortality is useful in identifying new maternal deaths. Existing databases can be used relatively easily to augment routine surveillance of maternal mortality. (*Am J Public Health.* 2002;92:1319–1322)

Maternal mortality is an important measure of the health of nations and of communities and indicates disparities in health and access to health care.[1,2] Routine public health surveillance of maternal mortality is passive and has been shown to result in undercounts of maternal mortality rates.[3–10] The Centers for Disease Control and Prevention (CDC) and the American College of Obstetrics and Gynecology have called for use of active surveillance methods to improve identification of pregnancy-related deaths.[4] Identifying more cases may increase our ability to uncover new risk factors and opportunities for prevention.

Vital record linkage, review of autopsy records, and searches of hospital discharge databases have been used to detect higher percentages of maternal deaths.[3,5,6,11–13] Vital record linkage, which links birth or abortion files to women's death files, has been automated on an experimental basis, allowing a system of active surveillance that is relatively easy to use and has high sensitivity and specificity.[11] New York City and other reporting areas have sought to improve surveillance of maternal mortality by adding a check box to death certificates to indicate a recent pregnancy.[3]

Because many maternal deaths occur during hospital admissions, the availability of hospital discharge databases raises the possibility of computerized active surveillance of maternal mortality. Our goal was to test the usefulness of a hospital discharge database and an autopsy record search as methods of active surveillance of maternal mortality in New York City for 1997.

METHODS

Case Definition

Routine surveillance used the World Health Organization (WHO) definition of maternal mortality: an *International Classification of Diseases, Ninth Revision* (*ICD-9*) code in the 630 to 676 range (deaths caused by pregnancy and occurring during pregnancy or within 42 days of termination).[14] For active surveillance, we used the following definition: any death caused by pregnancy and occurring before or on the 42nd day after termination of pregnancy. This included malignancy of the placenta (*ICD-9* code 181.0),[15,16] which is not part of the WHO definition.

Data Sources and Case Selection

Routine surveillance. The New York City health department routinely receives death certificates, either from the medical examiner or from reporting physicians, that are coded as "maternal" by nosologists. Codes are assigned according to the *ICD-9* system and are based on the cause(s) listed. We reviewed all maternal deaths reported in 1997.[17]

Hospital discharge data. The Statewide Planning and Research Cooperative System (SPARCS) contains records for all hospital discharges occurring in New York State.[18] We obtained a file of all SPARCS records pertaining to females aged 10 to 65 years who died in New York City hospitals in 1997. Each SPARCS record contained the disposition (i.e., discharged, transferred, deceased) and up to 31 diagnostic and procedure codes from *ICD-9,* as well as the medical record number, race/ethnicity, insurance status, and age of each patient.

To identify codes used in the hospital discharge database that might indicate pregnancy, we reviewed the *ICD-9* and New York State diagnosis-related group (DRG) categories (the latter describe reasons for hospital admissions and the treatments received by patients). A physician (Daniel J. Pallin) with computer programming expertise spent approximately 300 hours studying the SPARCS system, reviewing the *ICD-9* and DRG systems, and writing the programs to identify the deaths (using SAS, version 6.12). In addition to the *ICD-9* codes that explicitly indicate maternal causes of death (630–676), we selected 152 other diagnostic and procedural codes that indicated pregnancy, including 792.3 (abnormal finding, amniotic fluid), V22 (normal pregnancy), and 69.01 (dilation and curettage for termination of pregnancy). Records bearing any of these codes were flagged via the search.

Autopsy record database. Narrative autopsy reports containing gross anatomic findings, microscopic examination results, and final causes of death are stored as text files by the Office of the Chief Medical Examiner. We used Microsoft Windows to search these files for all documents that contained any of the following words or word fragments: *gesta-, preg-, amni-, abortion, ectopic,* and *placenta.* This search required approximately 2 hours.

Medical records. We reviewed obstetric and other medical records for all cases flagged to confirm that these cases involved maternal deaths, to verify causes of death, and to collect data on characteristics such as race/ethnicity, insurance status, and age.

Data Analysis

Analyses were conducted with SAS. We noted the sensitivity and ease of use of each surveillance method and compared, according to method used, demographic data for cases found. Causes of maternal death were tabulated. These causes were determined via medical record review by a physician (Daniel J. Pallin) rather than through the *ICD-9* codes noted on death certificates.

RESULTS

Case Ascertainment

Seventeen maternal deaths were reported through routine surveillance, producing a maternal mortality ratio (MMR) of 13.8 deaths per 100 000 live births (123 313 live births were reported in New York City in 1997).[17] After medical record review, 1 of these 17 deaths was found not to be a maternal death, resulting in a verified routine surveillance MMR of 13.0. Active surveillance detected 14 additional maternal deaths, an 88% increase, for a total of 30 maternal deaths during 1997 and an active surveillance MMR of 24.3.

Of the 14 maternal deaths newly identified via active surveillance, 9 (64%) were found through the SPARCS hospital discharge database search alone, and 1 (7%) was found via the autopsy database search alone. The remaining 4 deaths were found with both search methods. All 16 routine surveillance deaths were found by at least 1 of the active surveillance methods; the SPARCS search found 13 (81%), and the autopsy database search found 12 (75%; Table 1).

Assessment of Active Surveillance Search Methods

The hospital discharge search detected all but 4 (13%) of the 30 maternal deaths occurring in 1997. Of these 4 deaths, only 1 occurred among patients admitted to the hospital; this death was missed as a result of hospital clerical error. The other 3 occurred at the patient's home or in an emergency department, and hospital discharge records are not generated in such cases. Therefore, in the case of the hospital discharge database search, the sensitivity rates were 87% for all maternal deaths and 96% for inpatient maternal deaths.

The hospital discharge database search flagged 32 cases for 1997, of which 26 were confirmed as maternal deaths. Of the remaining 6 cases, 4 involved pregnant women who had not died; clerical error was possibly the reason they were listed as deceased. In addition, 2 deaths did not result from pregnancy complications. This led to a false-positive rate of 19% (6 of 32).

The autopsy database search flagged a total of 17 maternal deaths for 1997. Of these deaths, 2 were missed with routine surveillance owing to coding error, and 2 were missed because the contribution of pregnancy was not accurately noted on the death certificate.

Epidemiological Analysis

Table 2 displays selected characteristics of the 30 confirmed maternal deaths. There were no significant differences in any of these characteristics between the cases found by routine and those found by active surveillance.

There were notable, but not statistically significant, differences in causes of death among cases found via routine and those found via active surveillance. As a result of differences in definition, the 2 deaths due to choriocarcinoma were identified only by active surveillance. Deaths resulting from medical interventions accounted for more deaths missed by routine surveillance than did any other category (Table 3). Of the 30 maternal deaths, 7 resulted from medical intervention, and only 2 of these deaths were identified via routine surveillance. The other 5 deaths were the result of the following: probable adverse reaction to a medication, complications of elective anesthesia, complications of manual placental extraction, and cesarean delivery complications.

DISCUSSION

This study demonstrates that routine maternal mortality surveillance in New York City results in underestimates of maternal mortality and that additional deaths can be detected via active surveillance. For 1997, active surveillance using 2 computerized databases increased the case ascertainment rate by 88%. This resulted in an MMR of 24.3, as compared with 13.0 for routine surveillance. The increase in case ascertainment can be explained, in part, by our expansion of the definition of maternal mortality to include choriocarcinoma. However, this led to the addition of only 2 deaths. Use of the traditional definition of maternal mortality would still have increased case ascertainment by 75%.

Our results allow certain conclusions to be drawn about the utility of computerized databases for active maternal mortality surveillance. Hospital discharge database searches detected 87% of the maternal deaths occurring in 1997. This rate compared favorably with routine surveillance, which detected only 53% of the deaths. Hospital discharge search was especially sensitive in the case of inpatient maternal deaths, detecting 96% of these deaths. The initial programming for this search involved a relatively substantial time allocation, but once the program is written and verified, this method can be used relatively easily in subsequent years to detect maternal deaths in areas that maintain hospital discharge databases.

TABLE 1—Number of Maternal Deaths Found, by Search Method: New York City, 1997

	Search Method			
	Vital Statistics	Hospital Discharge	Autopsy Database	Any Method
Previously identified	16	13	12	16
New results	0	13	5	14
Found by method alone	0	9	1	10
Total	16	26	17	30

TABLE 2—Demographic Characteristics Associated With Cases of Maternal Death Identified Through Routine and Active Surveillance: New York City, 1997

Characteristic	Routine Alone (n = 16)	Active Alone (n = 14)	Total (n = 30)
Race/ethnicity, No.			
White non-Hispanic	2	5	7
Black non-Hispanic	9	8	17
Hispanic	2	1	3
Asian	1	0	1
Unknown	2	0	2
Insurance, No.			
Medicaid or self-pay	9	9	18
Health maintenance organization or third party	7	5	12
Age, y, mean (SD)	32.9 (5.9)	32.5 (7.0)	

TABLE 3—Causes of Maternal Death: New York City, 1997

Cause of Death	Routine Surveillance (n = 16), No.	Active Surveillance (n = 14), No.	Total (n = 30), No.
Eclampsia	2	1	3
Complications of therapy	2	5	7
Puerperal infection	0	1	1
Malignancy of placenta	0	2	2
Pulmonary embolism	7	1	8
DIC/ectopic	0	1	1
Subarachnoid hemorrhage	0	2	2
Thoracic aortic aneurysm	0	1	1
Amniotic fluid embolism	3	0	3
DIC/abruptio placentae	1	0	1
Uterine rupture	1	0	1

Note. Causes of death were determined on the basis of medical record review by a physician rather than the *ICD-9* codes noted on the death certificate. DIC = disseminated intravascular coagulation.

The autopsy database search was performed with minimal effort and required a limited amount of time. This method complemented hospital discharge searches by identifying deaths that occurred outside hospitals.

The use of computerized databases permits flexibility in defining the target of surveillance. For example, in this study we could easily have broadened our definition to include all deaths occurring within a year of pregnancy, as advocated by CDC and the American College of Obstetrics and Gynecology.[4] We also had the ability to include other causes of death that may be deemed maternal but that are not included in the maternal *ICD-9* code range. Although the tenth revision of the ICD (*ICD-10*) accounts for pregnancy-related deaths that occur more than 42 days after pregnancy termination, active surveillance would still detect cases missed by routine surveillance.[19]

Our study also shows that verification of surveillance results via medical record review is important. Our review revealed a false-positive rate of 19% for the hospital discharge search, as well as 1 false positive among the cases reported through routine surveillance.

An important limitation of this study was that we did not use vital records linkage, which has been demonstrated to be a successful method of increasing case ascertainment for maternal deaths.[5,6,11] A study involving these 2 methods, vital records linkage and hospital discharge search, would be useful.

This study demonstrates not only that active surveillance increases case ascertainment but also that causes of death differ according to surveillance method. The finding that medical interventions were the second highest contributor to maternal deaths and were the most likely to be missed by routine surveillance highlights the importance of active maternal mortality surveillance.

In conclusion, routine surveillance of maternal mortality should be augmented by periodic or continuous active surveillance. Incorporation of computer-assisted active surveillance will improve case finding and, if desired, permit a broadening of the existing definition of maternal mortality. However, we urge that whenever MMRs are estimated through active surveillance methods, the reported ratio be labeled "active surveillance maternal mortality ratio" to avoid misinterpretation of the ratio as an increase in maternal mortality. ■

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Daniel J. Pallin, Vandana Sundaram, Fabienne Laraque, and Louise Berenson are with the New York City Department of Health. At the time of the study, Daniel J. Pallin was also with the Preventive Medicine Residency Program, Brigham and Women's Hospital, Boston, Mass. Vandana Sundaram and Fabienne Laraque are with the Health Information Services Unit, Maternal, Infant and Reproductive Health Program. Louise Berenson is with the Office of Vital Statistics. David R. Schomberg is with the Office of the Chief Medical Examiner, New York City.

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Contributors

D.J. Pallin formulated the research questions, did the background research, obtained regulatory and ethical approval, planned the investigation, collected and assembled the data, conducted the analyses, and drafted the article. V. Sundaram evaluated the applicability of the data to the research questions, managed the databases, conducted analyses, was responsible for composing major portions of the article, and edited the article. F. Laraque did background research, oversaw the regulatory approval process, collected data, conducted analyses, was responsible for major portions of the article, and reviewed and edited the article. L. Berenson and D.R. Schomberg contributed to data gathering, checking of data, and drafting and editing of the article.

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Human Participant Protection

This study was approved by the New York Statewide Planning and Research Cooperative System Data Protection Review Board and by the New York City Department of Health Institutional Review Board.

References

1. Centers for Disease Control and Prevention. Differences in maternal mortality among black and white women—United States, 1990. *JAMA.* 1995;273:370–371.
2. Mertz KJ, Parker AL, Halpin GJ. Pregnancy-related mortality in New Jersey, 1975–1989. *Am J Public Health.* 1992;82:1085–1088.
3. Allen MH, Chavkin W, Marinoff J. Ascertainment of maternal deaths in New York City. *Am J Public Health.* 1991;81:380–382.
4. Atrash HK, Rowley D, Hogue CJ. Maternal and perinatal mortality. *Curr Opin Obstet Gynecol.* 1992;4:61–71.
5. May WJ, Buescher PA. Enhanced maternal mortality surveillance in North Carolina, 1988 and 1989. *MMWR Morb Mortal Wkly Rep.* 1991;40:469–471.
6. Floyd V, Hadley C, Lavoie M, et al. Pregnancy-related mortality—Georgia, 1990–1992. *MMWR Morb Mortal Wkly Rep.* 1995;44:93–96.
7. Starzyk P, Frost F, Kobayashi JM. Misclassification of maternal deaths—Washington State. *MMWR Morb Mortal Wkly Rep.* 1986;35:621–623.
8. Benedetti TJ, Starzyk P, Frost F. Maternal deaths in Washington State. *Obstet Gynecol.* 1985;66:99–101.
9. Comas A, Navarro A, Conde J, et al. Misreporting of maternal mortality in Puerto Rico. *Bol Asoc Med P R.* 1990;82:343–346.
10. Schuitemaker N, Van Roosmalen J, Dekker G, et al. Underreporting of maternal mortality in the Netherlands. *Obstet Gynecol.* 1997;90:78–82.
11. Jocums S, Mitchel EP Jr. Monitoring maternal mortality using vital records linkage. *Am J Prev Med.* 1995;11:75–78.
12. Dye TD, Gordon H, Held B, et al. Retrospective maternal mortality case ascertainment in West Virginia, 1985 to 1989. *Am J Obstet Gynecol.* 1992;167:72–76.
13. Nannini A, Weiss J, Kim J, et al. Enhanced maternal mortality surveillance in Massachusetts. In: Abstracts of the Maternal, Infant, and Child Health Epidemiology Workshop, December 1999, Atlanta, Ga.
14. *Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death, 9th Revision.* Geneva, Switzerland: World Health Organization; 1977.
15. Scott JR, ed. *Danforth's Obstetrics and Gynecology.* 7th ed. Philadelphia, Pa: Lippincott-Raven; 1994:1042.
16. DeVita VT. *Cancer: Principles and Practice of Oncology.* 5th ed. Philadelphia, Pa: Lippincott-Raven; 1997:1501.
17. Office of Vital Statistics. *Summary of Vital Statistics 1997, the City of New York.* New York, NY: New York City Dept of Health; 1998.
18. *Statewide Planning and Research Cooperative System (SPARCS).* Albany, NY: New York State Dept of Health; 1999.
19. *International Statistical Classification of Diseases and Related Health Problems, 10th Revision.* Geneva, Switzerland: World Health Organization; 1992.

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