Causes of Maternal Mortality in Japan

Ken Nagaya, MD
Michael D. Fetters, MD, MPH, MA
Mutsuo Ishikawa, MD
Takahiko Kubo, MD
Takashi Koyanagi, MD
Yoshiharu Saito, MD
Hiroshi Sameshima, MD
Mitsuhiro Sugimoto, MD
Koichiro Takagi, MD
Yoshihide Chiba, MD
Hiroshi Honda, MD
Masaaki Mukubo, MD
Mitsuhiro Kawamura, MD
Shoji Satoh, MD
Reiko Neki, MD

SYSTEMATIC IDENTIFICATION OF factors contributing to adverse events in health care and mechanisms for reducing their occurrence have been used in hospitals, long-term care facilities, and the outpatient setting.1,10 The need to comprehensively examine factors contributing to maternal mortality in Japan prompted our study of the Japanese obstetrics system.

The obstetrics system in Japan differs greatly from those of European and American countries. First, a distinguishing characteristic of the Japanese system is the low ratio of obstetricians per medical facility,11,12 there are approximately 11000 medical facilities in Japan, including hospitals and clinics, that provide ambulatory or inpatient obstetric services, but only 14000 obstetricians (including residents), for an average of 1.4 physicians per obstetric facility. Second, a majority of facilities do not have anesthesiologists, and 1 physician commonly serves as obstetrician and anesthetist. Third, obstetricians are the only specialists routinely delivering babies. There is virtually no tradition of family physicians providing obstetric care. Moreover, only about 1% of Japan’s nurse-midwives practice independently; they usually function as an assistant to the obstetrician and, with the exception of cutting the umbilical cord.

For editorial comment see p 2712.

Context Japan’s maternal mortality rate is higher than that of other developed countries.

Objectives To identify causes of maternal mortality in Japan, examine attributes of treating facilities associated with maternal mortality, and assess the preventability of such deaths.


Subjects Of 230 women who died while pregnant or within 42 days of being pregnant, 197 died in a hospital and had medical records available, 22 died outside of a medical facility, and 11 did not have records available.

Main Outcome Measures Maternal mortality rates per 100000 live births by cause (identified by death certificate review and information from treating physicians or coroners); resources and staffing patterns of facilities where deaths occurred; and preventability of death, as determined by a 42-member panel of medical specialists.

Results Overall maternal mortality was 9.5 per 100000 births. Hemorrhage was the most common cause of death, occurring in 86 (39%) of 219 women. Seventy-two (37%) of 197 deaths occurring in facilities were deemed preventable and another 32 (16%) possibly preventable. Among deaths that occurred in a medical facility with an obstetrician on duty, the highest rate of preventable deaths (4.09/100000 live births) occurred in facilities with 1 obstetrician. Among the 72 preventable deaths, 49 were attributed to 1 physician functioning as the obstetrician and anesthetist. While the unpreventable maternal death rate was highest in referral facilities, the preventable maternal death rate was 14 times lower in referral facilities than in transferring facilities.

Conclusions Inadequate obstetric services are associated with maternal mortality in Japan. Reducing single-obstetrician only delivery patterns and establishing regional 24-hour inpatient obstetrics facilities for high-risk cases may reduce maternal mortality in Japan.
CAUSES OF MATERNAL MORTALITY IN JAPAN

are not permitted to perform obstetrical procedures. Finally, while perinatal and infant mortality rates in Japan are the lowest worldwide, maternal mortality is relatively high. For example, the reported maternal mortality rates in 1990 for Japan, the United States, United Kingdom, and Canada were 8.6, 8.2, 7.6, and 2.4 per 100,000 live births, respectively, and absence of cross-checking for deaths from sources other than death certificates in Japan suggests the true rate is even higher.

The Confidential Inquiry into Maternal Deaths Research Group (CIMDRG) was created in 1995 to study ways of reducing maternal mortality. The group investigated the history of each maternal death during a 2-year period, identified factors associated with maternal mortality, and made recommendations for reducing maternal mortality. This inquiry was initiated by the Japanese Ministry of Health and Welfare because of concern about the high rate of maternal mortality in Japan. One of the authors (K.N., director of the group) recruited the 14 additional members based on their expertise and interest in reduction of maternal mortality. The CIMDRG participants only received financial support for research-associated expenses.

METHODS

The group systematically investigated circumstances of known maternal deaths by examining death certificates, scrutinizing the circumstances of each death, and assessing its preventability.

Comprehensive Investigation of Maternal Deaths

Although laws governing vital statistics restrict their use to calculating death statistics, after 9 months of negotiations, the CIMDRG successfully petitioned the Japanese government for permission to examine all maternal death certificates from the study period. Since government approval had been granted to conduct the investigation, approval of institutional review boards of the target hospitals or surrogates was not sought. All efforts were made to protect participant confidentiality. Cases meeting the International Classification of Diseases, Ninth Revision (ICD-9) maternal death definition, “the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration of pregnancy or its management, but not from accidental or incidental causes” qualified for this investigation. Death certificates do not require indication of current or recent pregnancy, and no other sources of maternal deaths were identified.

Using the contact information contained in the death certificates, we telephoned the medical facilities that provided medical care to the study participants at any time during the pregnancy; for deaths that occurred outside a medical facility, we contacted the office of the coroner. After explaining the study and obtaining consent for participation by phone, we mailed a questionnaire to the physician, facility representative, or coroner contacted. The 59-page questionnaire contained approximately 600 questions and elicited detailed information about the clinical history of each death, facility characteristics, what personnel participated in the patient’s care, and the available daytime and nighttime staffing and laboratory services. Two weeks after mailing the questionnaire, a CIMDRG researcher visited the medical facilities or coroner’s office to investigate the case by reviewing the questionnaire and interviewing individuals knowledgeable about the case.

We calculated demographics and maternal mortality rates. Medical facilities were divided into 3 groups: nontransferring facilities were sites where patients received all their care in the same facility and died with no history of transfer; transferring medical facilities provided initial care, then transferred the patient to a receiving facility, where patients ultimately died. Nontransferring hospitals were generally larger than transferring facilities, while receiving facilities were the largest. We examined the distribution of maternal deaths by facility and pattern of transfer; medical facility characteristics; staffing and facility operating patterns; and availability of laboratory and diagnostic services. We determined the obstetrical characteristics and causes of the maternal deaths.

Preventable Maternal Deaths

The CIMDRG invited national authorities renowned for clinical expertise to participate in a Preventability Assessment Committee. This committee for determining preventability of maternal deaths included 42 medical specialists in obstetrics and gynecology, anesthesiology, neurosurgery, emergency medicine, and pathology. At the outset, the committee determined that a mistake or error must have occurred for an event to qualify as preventable. During four 3-day sessions, the records of all 197 women who received care in a medical facility and died and for whom records were available were reviewed 1 at a time by the committee.

To maximize consistency in evaluation, cases were clustered according to cause of death. The CIMDRG member who investigated the death presented to the committee the case history, physical findings, diagnostic results, autopsy findings, and associated interview data. After in-depth group discussion of each case, each member anonymously voted on the preventability of death for each case. Committee members assigned 1 of 4 preventability categories: (1) impossible to prevent; (2) difficult, but possible to prevent; (3) not difficult to prevent; and (4) indeterminable. For study purposes, the conservative criteria for a preventable death were defined as no committee member selected impossible to prevent and at least 70% of committee members chose not difficult to prevent. Each committee member assessed for deficiencies in ambulatory and hospital care and whether the care met the basic community practice standard. Seventy percent or more of the committee members had to agree to conclude failure to meet the basic community practice standard.
Based on the CIMDRG investigation and published data from other investigations, we calculated mortality rates for unpreventable and preventable deaths by number of obstetricians per facility type and mortality rates for the subset of preventable maternal deaths due to hemorrhage that occurred during the critical period of death preventability (onset of serious symptoms to the time of inevitable death, ie, apnea or cardiac arrest, or actual death). Finally, we examined the distribution of maternal deaths by characteristics of the facility rendering treatment during the critical period of death preventability (ie, the number of obstetricians and anesthetists and availability of laboratory services). Because the current analysis accounted for the entire population of cases, we did not perform inferential statistical calculations.

RESULTS

Based on the ICD-9 classification system, there were 230 maternal deaths between January 1, 1991, and December 31, 1992, with 115 deaths in each year. Ninety percent of the deceased were married, and 96% were Japanese nationals. The deaths were distributed throughout Japan. Mortality increased exponentially for women aged 35 years and older (Table 1). For 197 deaths (85.7%), at least 1 medical facility where the patient received care participated in the investigation. Twenty-two of the deceased (9.6%) never sought medical care for their pregnancy and died outside a medical facility. We could not investigate 11 deaths (4.8%) because 3 facilities refused participation; 5 had no patient records; and 3 were closed.

Of 327 medical facilities contacted, 312 (95%); 81 clinics with beds, 57 university hospitals, 67 public hospitals, 106 private hospitals, and 1 midwife’s maternity home) where the 197 women received care participated. Of the 15 nonparticipating facilities that transferred patients, 7 refused participation, and 8 had closed. Participating facility categories included 82 nontransferring facilities (26%); 115 transferring medical facilities (37%); and 115 receiving medical facilities (37%) (Table 2). Maternal death distribution by timing relative to delivery was 84 predelivery deaths (43%), 61 post-delivery deaths (31%), and 52 deaths without delivery (26%). Of these maternal deaths, 104 (53%) occurred in receiving facilities after the woman was transferred once from a transferring facility and 12 (6%) occurred in receiving facilities after the women was transferred 2 or more times.

Transferring facilities were the smallest (mean [SD] number of general beds, 105.8 [214.8]), nontransferring facilities (mean [SD] number of general beds, 316.4 [266.3]) were intermediate in size, and receiving facilities were the largest (mean [SD] number of general beds, 576.9 [295.0]). Both the total [SD] number of deliveries (transferring, 358.8 [357.5]; nontransferring, 502.1 [433.4]; and receiving facilities, 529.2 [311.7]) and cesarean delivery rate (transferring, 38.1 [51.8], nontransferring, 60.5 [59.4]; and receiving facilities, 80.4 [57.2]) increased in a similar pattern. Few transferring facilities had intensive care services, and physicians’ estimations of the length of time from decision to perform cesarean delivery until incision of the abdomen for all patients treated in their facilities was 9 to 16 minutes longer in transferring than receiving facilities other than university hospitals. There was a very large SD in length of time until cesarean delivery, particularly on weekends and holidays.

There was a precipitous decrease in on-duty (staff available in the hospital) obstetricians, anesthesiologists, operating room nurses, and neonatologists in all facilities during weekends and evenings (Table 3). There were differences in on-duty staff within each facility group when university and nonuniversity hospitals were compared. For example, in receiving facilities, the mean (SD) number of obstetricians was 16.6 (6.8) and 4.4 (3.5) for university and nonuniversity hospitals, respectively. The trend for fewer staff in nonuniversity hospitals was seen for anesthesiologists, operating room nurses, and neonatologists. At night and on weekends or holidays, the mean (SD) number of on-duty obstetricians was 1.9.

©2000 American Medical Association. All rights reserved.

(Reprinted) JAMA, May 24/31, 2000—Vol 283, No. 20 2663

Table 1. Maternal Mortality Rate per 100 000 Live Births by Maternal Age, Japan, 1991-1992

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Maternal Deaths, No.</th>
<th>Total No. of Live Births</th>
<th>Maternal Deaths per 100 000 Live Births</th>
<th>Relative Risk of Maternal Mortality*</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤19</td>
<td>2</td>
<td>36 835</td>
<td>5.4</td>
<td>0.57</td>
</tr>
<tr>
<td>20-24</td>
<td>19</td>
<td>405 742</td>
<td>4.7</td>
<td>0.45</td>
</tr>
<tr>
<td>25-29</td>
<td>64</td>
<td>1065 305</td>
<td>6.0</td>
<td>0.49</td>
</tr>
<tr>
<td>30-34</td>
<td>68</td>
<td>714 823</td>
<td>9.5</td>
<td>1.01</td>
</tr>
<tr>
<td>35-39</td>
<td>45</td>
<td>183 821</td>
<td>24.5</td>
<td>2.98</td>
</tr>
<tr>
<td>40-44</td>
<td>29</td>
<td>25 100</td>
<td>115.5</td>
<td>13.85</td>
</tr>
<tr>
<td>≥45</td>
<td>3</td>
<td>553</td>
<td>542.5</td>
<td>58.43</td>
</tr>
<tr>
<td>Total</td>
<td>230</td>
<td>24 321 179</td>
<td>9.5</td>
<td>NA</td>
</tr>
</tbody>
</table>

*Risk is for respective age group vs all others. NA indicates not applicable.

Table 2. Types of Medical Facilities by Number of Maternal Deaths, Japan, 1991-1992

<table>
<thead>
<tr>
<th>Type of Medical Facility</th>
<th>Nontransferring (n = 82)</th>
<th>Transferring (n = 115)</th>
<th>Receiving (n = 115)</th>
<th>Total, No. (%) (N = 312)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinic with beds</td>
<td>13</td>
<td>65</td>
<td>3</td>
<td>81 (26)</td>
</tr>
<tr>
<td>University hospital</td>
<td>11</td>
<td>5</td>
<td>41</td>
<td>57 (18)</td>
</tr>
<tr>
<td>Other hospital</td>
<td>58</td>
<td>44</td>
<td>71</td>
<td>173 (55)</td>
</tr>
</tbody>
</table>

*Mwoctives’ maternity home | 0 | 1 | 0 | 1 (<1)

*Nontransferring indicates medical facilities where patients were never transferred; transferring, medical facilities that transferred patients to receiving facilities; and receiving, medical facilities where the patients ultimately died after transfer from a transferring facility.

†Percentages do not sum to 100% because of rounding.
CAUSES OF MATERNAL MORTALITY IN JAPAN

Table 3. Staffing Patterns of Medical Facilities Where Maternal Deaths Occurred by History of Transfer, Japan, 1991-1992*

<table>
<thead>
<tr>
<th>Staffing Pattern</th>
<th>Mean No. (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nontransferring (n = 82)</td>
</tr>
<tr>
<td></td>
<td>Transferring (n = 115)</td>
</tr>
<tr>
<td></td>
<td>Receiving (n = 115)</td>
</tr>
<tr>
<td>Obstetrician/gynecologist on duty†</td>
<td>3.3 (2.6)</td>
</tr>
<tr>
<td>Total staff</td>
<td>0.5 (0.6)</td>
</tr>
<tr>
<td>Evenings and weekend daytime</td>
<td>0.6 (1.7)</td>
</tr>
<tr>
<td>Anesthesiologists on duty†</td>
<td>0.1 (0.3)</td>
</tr>
<tr>
<td>Total staff</td>
<td>0.5 (0.9)</td>
</tr>
<tr>
<td>Operating room nurses on duty</td>
<td>0.1 (0.3)</td>
</tr>
</tbody>
</table>

†Numbers include residents and house officers.

Table 4. Obstetrical Characteristics of Maternal Deaths, Japan, 1991-1992 (n = 197)*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparatory care</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular</td>
<td>158 (80)</td>
<td></td>
</tr>
<tr>
<td>Some</td>
<td>8 (4)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>21 (11)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>10 (5)</td>
<td></td>
</tr>
<tr>
<td>Gravity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primiparous</td>
<td>73 (37)</td>
<td></td>
</tr>
<tr>
<td>Multiparous</td>
<td>114 (58)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>10 (5)</td>
<td></td>
</tr>
<tr>
<td>Mode of delivery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cesarean</td>
<td>73 (37)</td>
<td></td>
</tr>
<tr>
<td>Emergent</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Vaginal</td>
<td>72 (37)</td>
<td></td>
</tr>
<tr>
<td>Unassisted in medical facility</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Vacuum assisted</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Home births</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Breach extraction</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Forceps assisted</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Died prior to delivery</td>
<td>52 (26)</td>
<td></td>
</tr>
</tbody>
</table>

*Nontransferring indicates medical facilities where patients were never transferred; transferring, medical facilities that transferred patients to receiving facilities; and receiving, medical facilities where the patients ultimately died after transfer from a transferring facility.

Examination of Maternal Deaths and Their Causes

The obstetrical characteristics of the 197 in-hospital maternal deaths are depicted in Table 4. Most women (80%) received regular prenatal care. Primiparous women accounted for 37% of cases, and 58% of women were multiparous. Twenty women of the latter group had a history of 1 or more cesarean deliveries. Of the 197 pregnancies, 73 (37%) were cesarean deliveries, of which 63 were conducted emergently, and 10 were elective. Of the 72 vaginal deliveries (37%), most (44) were normal spontaneous deliveries occurring in a medical facility, although there were also 5 births outside a medical facility. Seventeen deliveries required vacuum assistance, and there were 3 forceps deliveries and 3 breech extractions. Fifty-two women (26%) died prior to delivery. Eighteen women (9%) had a total abdominal hysterectomy, and 10 women (5%) had a subtotal hysterectomy to control brisk bleeding. Autopsy was performed in 44 cases (22%).

Causes of maternal deaths in the participating facilities are shown in Table 5; the most common causes of death were antepartum and postpartum hemorrhage. Coroner examination was performed for the 22 cases that were not under the care of a physician at the time of death (Table 5). These causes were similar except for the proportionately large number of deaths, 4 (18%), attributed to acute heart failure.

Assessment of Preventability

Seventy-two cases (37%) met the 2 criteria for being preventable. First, in all of these cases, none of the committee members selected impossible to prevent. Second, in 19 cases, all the members selected not difficult to prevent, and in the other 53 cases, 70% or more of the committee members selected not difficult to prevent. Of these 72 cases, there were 46 deaths due to antepartum and postpartum hemorrhage, 10 deaths secondary to hypertensive disorders of pregnancy, 4 deaths associated with anesthesia, 3 deaths each due to multiple organ failure associated with coagulopathy and hyperemesis gravidarum, 1 death each due to intracerebral hemorrhage, pulmonary embolism, sepsis, and an indirect cause. Two deaths were unexplained.

Of preventable deaths, 49 (68%) were attributable to the physician attempting to act as both the obstetrician and anesthetist: 46 cases of antepartum and postpartum hemorrhage and 3 cases of anesthesia complications. Of the 72 preventable deaths, there were 45 cases (63%) with deficiencies in hospital care; 9 cases (13%) with deficiencies in ambulatory and inpatient care; 7 cases (10%) with deficiencies in ambulatory care; and 11 cases (15%) for which consensus was unobtainable. The committee judged there was failure to meet a basic community practice standard in 36 cases (50%).

An additional 32 deaths (16%) were deemed possibly preventable. In 28 cases, no committee member picked impossible to prevent and in 4 cases, 70% or more of the committee members selected not difficult to prevent, but 1 committee member selected impossible to prevent. Of these deaths, only 11 (34%) were associated with hemorrhage and 7 (21.8%) with indirect cause, 5 (15.6%) with unexplained causes, and 9 (28%) with distribution similar to that of preventable causes.

Among unpreventable deaths that occurred in a medical facility with an-
stetrician on duty, the mortality rate was highest in facilities with 4 or more obstetricians, although among preventable deaths, the mortality rate for facilities with only 1 obstetrician was higher than facilities with 2 or more obstetricians (Table 6). As the number of obstetricians working at a facility increased, the maternal mortality rate for preventable deaths due to hemorrhage decreased: 3.80 for 1 obstetrician per facility; 0.47 for 2 to 3 obstetricians per facility; and 0 for 4 or more obstetricians per facility. National data on staffing patterns of anesthesiologists and availability of laboratory services do not exist and so calculating the maternal mortality rate for these variables was precluded.

The distribution of maternal deaths by facility that rendered treatment during the critical period of preventability revealed a dramatic decrease in the rate per 100,000 going from the smallest to largest facilities—56 for transferring facilities, 26 for nontransferring facilities, and 4 for receiving facilities (Table 7). Thus, the preventable maternal death rate was 14 times higher in transferring facilities and 6.5 times higher in nontransferring facilities than in receiving facilities. We also examined the proportion of unpreventable and preventable deaths according to the obstetric and anesthetic staffing and laboratory services during the critical period of preventability. Table 8 illustrates a dramatic decrease in the proportion of preventable deaths as the number of obstetricians on duty during the critical period increased. Although relatively few facilities were staffed with anesthesiologists, the trends for their participation when present were similar, and the proportion of preventable deaths was essentially unchanged when combining the number of obstetricians and anesthesiologists. This suggests that if a critical factor is staffing—there were fewer maternal deaths when there were more physicians available to care for the patient. Finally, only a limited number of facilities where maternal deaths occurred provided continuous access to even basic laboratory services. For example, the percentage of facilities with 24-hour availability of 3 test panels were complete blood cell count, 50%; liver function testing, 45%; and coagulation studies, 20%.

**COMMENT**

Inadequate obstetric and anesthetic services and laboratory facilities are asso-

---

**Table 5. Causes of Maternal Deaths, Japan, 1991-1992**

<table>
<thead>
<tr>
<th>Cause</th>
<th>No. (Rate)</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemorrhage</td>
<td>74 (38)</td>
<td></td>
</tr>
<tr>
<td>Uterine rupture</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Atony</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Placental abruption</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>DIC of unknown etiology</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Ectopic pregnancy rupture or abortion</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Secondary to cesarean delivery</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>hysterection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Placenta previa</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Cervical or vaginal lacerations</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Unknown cause</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Intracranial hemorrhage</td>
<td>27 (14)</td>
<td></td>
</tr>
<tr>
<td>Intracerebral hemorrhage</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Hypertensive disorders of pregnancy</td>
<td>17 (9)</td>
<td></td>
</tr>
<tr>
<td>Pulmonary edema</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Hepatic necrosis due to HELLP syndrome</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Acute fatty liver</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>17 (9)</td>
<td></td>
</tr>
<tr>
<td>Amniotic embolism</td>
<td>7 (4)</td>
<td></td>
</tr>
<tr>
<td>Other direct causes</td>
<td>19 (10)</td>
<td></td>
</tr>
<tr>
<td>Sepsis</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Anesthesia complications</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Multiple organ failure due to DIC</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Hyperemesis gravidarum</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Spontaneous aspiration of gastric contents</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Adverse reaction to ritodrine</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>hydrochloride, furosemide, albinin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other indirect causes</td>
<td>19 (10)</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Pancytopenia secondary to viral infection</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Unexplained</td>
<td>17 (9)</td>
<td></td>
</tr>
</tbody>
</table>

**Table 6. Mortality Rates for Unpreventable and Preventable Deaths per 100,000 Live Births by the Number of Obstetricians, Japan, 1991-1992**

<table>
<thead>
<tr>
<th>Obstetricians on Duty, No.</th>
<th>Estimated No. of Live Births</th>
<th>Maternal Deaths, No. (Rate)</th>
<th>Unpreventable Maternal Deaths, No. (Rate)</th>
<th>Preventable Maternal Deaths, No. (Rate)</th>
<th>Preventable Maternal Deaths Due to Hemorrhage, No. (Rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0†</td>
<td>25 215</td>
<td>32 (127)</td>
<td>30 (119)</td>
<td>2 (7.93)</td>
<td>1 (3.97)</td>
</tr>
<tr>
<td>1</td>
<td>1 052 613</td>
<td>99 (9.41)</td>
<td>56 (5.32)</td>
<td>43 (4.09)</td>
<td>40 (3.80)</td>
</tr>
<tr>
<td>2-3</td>
<td>1 061 143</td>
<td>51 (4.81)</td>
<td>34 (3.2)</td>
<td>17 (1.60)</td>
<td>5 (0.47)</td>
</tr>
<tr>
<td>≥4</td>
<td>293 208</td>
<td>48 (16.3)</td>
<td>38 (12.9)</td>
<td>10 (3.41)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Total</td>
<td>2 432 179</td>
<td>230 (9.45)</td>
<td>158 (6.49)</td>
<td>72 (2.96)</td>
<td>46 (1.89)</td>
</tr>
</tbody>
</table>

*Rate is per 100,000 live births.
†This category includes 22 women who died outside a medical facility, 5 who died at home, and 5 who died in a facility with an obstetrician on call from home.

**Table 7. Distribution of Maternal Deaths by Facility Type Rendering Treatment During Critical Period of Death Preventability, Japan, 1991-1992**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Nontransferring</th>
<th>Transferring</th>
<th>Receiving</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total in-hospital maternal deaths, No.</td>
<td>82</td>
<td>104</td>
<td>11</td>
<td>197</td>
</tr>
<tr>
<td>Identified preventable maternal deaths treated during the critical period, No.</td>
<td>21</td>
<td>46</td>
<td>5</td>
<td>72</td>
</tr>
<tr>
<td>Live births per facility type, 1991-1992, No.</td>
<td>82 347</td>
<td>82 533</td>
<td>121 712</td>
<td>286 592</td>
</tr>
<tr>
<td>Rate of preventable maternal deaths per 100,000 population</td>
<td>26</td>
<td>56</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Ratio of preventable deaths rate to receiving facilities rate</td>
<td>6.5</td>
<td>14</td>
<td>1</td>
<td>6.3</td>
</tr>
</tbody>
</table>

*Nontransferring indicates medical facilities where patients were never transferred; transferring, medical facilities that transferred patients to receiving facilities; and receiving, medical facilities where the patients ultimately died after transferring to a transferring facility. Eleven deaths were not included in the analysis because 3 facilities refused participation, 5 had no patient records, and 3 were closed.

©2000 American Medical Association. All rights reserved.

(Reprinted) JAMA, May 24/31, 2000—Vol 283, No. 20 2665

---

**Table 8. Deaths Occurring in Medical Facilities (n = 197)**

<table>
<thead>
<tr>
<th>Cause</th>
<th>No. (Rate)</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemorrhage</td>
<td>74 (38)</td>
<td></td>
</tr>
<tr>
<td>Uterine rupture</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Atony</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Placental abruption</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>DIC of unknown etiology</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Ectopic pregnancy rupture or abortion</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Secondary to cesarean delivery</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>hysterection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Placenta previa</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Cervical or vaginal lacerations</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Unknown cause</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Intracranial hemorrhage</td>
<td>27 (14)</td>
<td></td>
</tr>
<tr>
<td>Intracerebral hemorrhage</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Hypertensive disorders of pregnancy</td>
<td>17 (9)</td>
<td></td>
</tr>
<tr>
<td>Pulmonary edema</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Hepatic necrosis due to HELLP syndrome</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Acute fatty liver</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>17 (9)</td>
<td></td>
</tr>
<tr>
<td>Amniotic embolism</td>
<td>7 (4)</td>
<td></td>
</tr>
<tr>
<td>Other direct causes</td>
<td>19 (10)</td>
<td></td>
</tr>
<tr>
<td>Sepsis</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Anesthesia complications</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Multiple organ failure due to DIC</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Hyperemesis gravidarum</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Spontaneous aspiration of gastric contents</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Adverse reaction to ritodrine</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>hydrochloride, furosemide, albinin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other indirect causes</td>
<td>19 (10)</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Pancytopenia secondary to viral infection</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Unexplained</td>
<td>17 (9)</td>
<td></td>
</tr>
</tbody>
</table>

*DIC indicates disseminated intravascular coagulation; HELLP, hemolysis, elevated liver enzymes and low platelet count. Percentages (in parentheses) do not sum to 100% because of rounding. Eleven deaths were not included in the analysis because 3 facilities refused participation, 5 had no patient records, and 3 were closed.

---

**Table 9. Deaths Occurring Outside Medical Facilities (n = 22)**

<table>
<thead>
<tr>
<th>Cause</th>
<th>No. (Rate)</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postpartum hemorrhage</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Acute heart failure</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Ectopic pregnancy</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Abortion</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Acute respiratory failure (cause unknown)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
associated with maternal mortality in Japan, Japan’s obstetricians are distributed among a large number of small hospitals that typically only have basic laboratory services and often only on a limited basis. Approximately 40% of Japan’s annual deliveries occur in clinics with 19 or fewer beds. Frequently, 1 physicians take care of all outpatients and inpatients, including deliveries (range, 100-1000 inpatient deliveries per year), 24 hours per day, 365 days per year. About 30% of annual deliveries occur in such small hospitals (mean [SD] number of general beds, 106 [215]), staffed by 1 or 2 physicians, where laboratory services are only available during the day on weekdays. The remaining 30% of annual deliveries occur in large hospitals (mean [SD] number of general beds, 577 [295]). Many of the obstetrics and gynecology departments in these hospitals have only 3 to 8 physicians (mean, 4), although in university hospitals the range is 10 to 20. In turn, these physicians take care of all the outpatients, inpatients, and deliveries (usually 300-1500 deliveries per year) all day and all night throughout the year. Only a small percentage of hospitals have 24-hour laboratory services and anesthesiology staffing.

Japan lacks a system to provide regional, round-the-clock, advanced care inpatient obstetrics coverage, and this deficiency may be contributing to the maternal mortality rate. Among women receiving medical care, facilities with only 1 obstetrician had the highest rates of preventable deaths from all causes and the highest rate for hemorrhagic deaths. Moreover, these criteria likely underestimate the magnitude of the problem. First, by very conservative preventability criteria, 72 women died from preventable medical errors—an additional 32 deaths were possibly preventable. Second, death certificate data underestimate maternal deaths because there is no requirement to note recent or current pregnancy. Third, the proportion of indirect deaths in our study is lower than other countries,19,20 a fact strongly suggesting that some maternal deaths occurring during the study period were never identified. Finally, these problems in underreporting may be exacerbated by legal concerns, although the magnitude of this effect is probably less important in Japan, which has a less litigious climate than the United States.

Maternal deaths secondary to hemorrhage are the most important cause of preventable deaths. Almost all of these could likely have been prevented if the patients had been treated by more than 1 obstetrician or by an obstetrician with assistance of at least 1 other clinician to manage the nonobstetric aspects of the patient’s care. Had these 40 hemorrhagic deaths alone been prevented, there would have been an estimated reduction in the 2-year overall maternal mortality rate of 17% (9.5/100000 to 7.8/100000) and in the preventable mortality rate of 56% (3.0/100000 to 1.3/100000).

Maternal mortality has decreased slightly since the time of the incident deaths in 1991-1992, for example, the rate in 1990 was 8.6/100000 (105/1221585) and in 1995 was 7.2/100000 (85/1187064), although the rate of potentially preventable causes has not changed. The maternal mortality rates attributable to hemorrhage and toxemia in 1990 and 1995 were 4.0/100000 (49/1221585) and 3.9/100000 (46/1187064), respectively. The decrease occurred primarily in the category of deaths attributable to ectopic pregnancy. The total maternal deaths in 1990 and 1995 were, respectively, 10 and 2 deaths secondary to ectopic pregnancy, 49 and 46 deaths secondary to hemorrhage or toxemia, 29 and 19 other direct obstetric deaths, and 14 and 18 indirect obstetric deaths. The increasing availability and diffusion over the past 8 years of highly sensitive home pregnancy kits and the standard obstetrics practice of performing ultrasound examination on virtually all pregnant patients is believed to have facilitated earlier detection and treatment of ectopic pregnancies and thus reduced the incident deaths. However, the system of obstetric care has not changed.

Table 8. Obstetrics and Anesthesiologist Staffing in Medical Facilities Rendering Treatment During Critical Period of Maternal Death Preventability, Japan, 1991-1992*  

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2-3</td>
</tr>
<tr>
<td>Total in-hospital</td>
<td>81†</td>
<td>90</td>
<td>51</td>
</tr>
<tr>
<td>Unpreventable</td>
<td>6 (75)</td>
<td>47 (52)</td>
<td>34 (67)</td>
</tr>
<tr>
<td>Preventable from all causes‡</td>
<td>2 (25)</td>
<td>43 (48)</td>
<td>17 (33)</td>
</tr>
<tr>
<td>Preventable from hemorrhage</td>
<td>1 (13)</td>
<td>40 (44)</td>
<td>5 (10)</td>
</tr>
</tbody>
</table>

*Data are given as No. (%) unless otherwise indicated. For all categories of maternal deaths, percentages are percentage of total deaths in staffing category. Eleven deaths were not included in the analysis because 3 facilities refused participation, 5 had no patient records, and 3 were closed.
†These women were treated in a medical facility by a physician other than an obstetrician.
‡Percentages of preventable deaths are given as percentage of total deaths.

©2000 American Medical Association. All rights reserved.
Recommendations for Reducing Maternal Mortality

The CIMDRG reached the following 4 conclusions. First, there is a need to designate regional obstetrics medical facilities to provide 24-hour inpatient obstetric coverage and to increase the number of physicians (especially obstetricians) on duty in regional facilities. Independent analysis concluded that there should be 14 staff obstetricians per hospital to provide adequate inpatient coverage. To achieve sufficient staffing, it may also be necessary to encourage a more active role of nonobstetrician obstetric providers such as family physicians and nurse midwives as in many other parts of the world. Japanese obstetricians and anesthesiologists should develop regional partnerships whereby small medical facilities provide local, ambulatory care for low-risk pregnant women, but the patients deliver at a designated regional medical facility. High-risk patients, such as women aged 35 years and older, should receive ambulatory and inpatient care in designated regional medical facilities. Selected obstetricians from small medical facilities should take rotating duty in the designated regional facilities.

Second, all Japanese hospitals that provide inpatient care for deliveries should be staffed with at least 1 obstetrician and another health provider, eg, an obstetrician or anesthesiologist, competent to provide nonobstetric medical care. All obstetric hospitals should be equipped to provide essential laboratory services. The occurrence of maternal massive bleeding and respiratory distress are relatively uncommon, but they are treatable events, and the same physician should never serve as the obstetrician and anesthetist. Separation of these roles should become the basic community standard. The Japanese government needs to develop policies providing financial incentives for recruiting adequate numbers of obstetricians and anesthesiologists to regional medical facilities.

Third, all death certificates need to be completed according to the ICD-10 classification that includes the additional definitions late maternal death (“death of a woman while pregnant or within 42 days of termination of pregnancy”); and pregnancy-related death (“death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death”). Educational efforts encouraging physicians to report this information are needed.

Finally, the Japanese government and the Japanese Society of Obstetrics and Gynecology need to develop clear community practice standards that delineate specific staffing and laboratory services necessary in each type of medical facility. To minimize medical errors, system-based changes are needed. While some maternal deaths are inevitable, this systems approach to change should reduce maternal mortality in Japan.

Acknowledgment: We gratefully acknowledge the assistance of Daniel W. Gorenflo, PhD, Department of Family Medicine, University of Michigan Health System, Ann Arbor.