Improving the Sensitivity and Specificity of the Abbreviated Injury Scale Coding System

CAROLINE F. KRAMER, RN
JEROME I. BARANCIK, ScD
HENRY C. THODE, JR., PhD

The authors are associated with Brookhaven National Laboratory's Injury Prevention and Analysis Group, Department of Applied Science. Ms. Kramer is Assistant Group Leader. Dr. Barancik is Group Leader, as well as Associate Professor and Director of the Injury Epidemiology Program, State University of New York, School of Medicine, Stony Brook. He is also Adjunct Associate Professor of Epidemiology, SUNY School of Public Health, Albany. Dr. Thode is a Statistical and Computer Analyst of the Injury Prevention and Analysis Group, and Assistant Professor, SUNY School of Medicine, Stony Brook.

This work was presented in part at the American Public Health Association annual meeting, New Orleans, LA, October 1987, and the First World Conference on Accident and Injury Prevention, Stockholm, Sweden, September 1989.

The project is supported by the U.S. Department of Transportation, National Highway Traffic Safety Administration, IAG DTNH22-85-C-00011, and the New York State Governor's Traffic Safety Committee, TR86-012. The AIS Training Manual is supported by the Department of Energy under contract DE-AC02-76CH00016.

Tearsheet requests to Caroline F. Kramer, RN, Injury Prevention and Analysis Group, Brookhaven National Laboratory, Building 475, Upton, NY 11973.

Synopsis

The Abbreviated Injury Scale with Epidemiologic Modifications (AIS 85-EM) was developed to make it possible to code information about anatomic injury types and locations that, although generally available from medical records, is not codable under the standard Abbreviated Injury Scale, published by the American Association for Automotive Medicine in 1985 (AIS 85).

In a population-based sample of 3,223 motor vehicle trauma cases, 68 percent of the patients had one or more injuries that were coded to the AIS 85 body region nonspecific category external. *When the same patients' injuries were coded using the AIS 85-EM coding procedure, only 15 percent of the patients had injuries that could not be coded to a specific body region. With AIS 85-EM, the proportion of codable head injury cases increased from 16 percent to 37 percent, thereby improving the potential for identifying cases with head and threshold brain injury.*

The data suggest that body region coding of all injuries is necessary to draw valid and reliable conclusions about changes in injury patterns and their sequelae. The increased specificity of body region coding improves assessments of the efficacy of injury intervention strategies and countermeasure programs using epidemiologic methodology.

EPIDEMIOLOGIC STUDIES of motor vehicle injuries and evaluation of vehicular injury prevention and control strategies have demonstrated a continuing need for improving the sensitivity and specificity of the classification systems used to define anatomic injury location and severity.

Much of the early research on impact or blunt injuries was conducted by DeHaven and colleagues at Cornell University, Dr. John Stapp of the U.S. Air Force, and Dr. William Haddon, Jr., the first administrator of the National Highway Safety Bureau, now the National Highway Traffic Safety Administration (*1*). Subsequent work by Dr. John States of the University of Rochester substantiated the need for enhanced understanding of the mechanisms and outcomes of vehicular injuries.

The first method for ranking and comparing the severity of motor vehicle injuries, as well as an injured person's likelihood of surviving the injury, was published in 1971 under the sponsorship of a joint committee of the American Medical Association, the American Association for Automotive Medicine, and the Society of Automotive Engineers (*2, 3*). Since then, the Abbreviated Injury Scale (AIS) has evolved into a widely used procedure for describing impact injury and its severity (*4, 5*). The compatibility between AIS and the International Classification of Diseases (*6*) is a complex methodologic issue. Dr. Ellen MacKenzie and coworkers at Johns Hopkins University have developed a computerized conversion table as a step in resolving this issue (*7*).

The 1985 revision of AIS incorporates several improvements over previous versions, including improved capability for coding concussive, internal, and vascular injuries (*2*). The clinical terminology used to describe injuries has been expanded and has become

more descriptive, particularly regarding thoracic, abdominal, and vascular injuries (*2, 8*). In addition, a unique six-digit numeric code to describe each injury and its level of severity has been added to provide users with a standardized format for coding and data analysis.

AIS 85 Components

The AIS 85 six-digit numeric coding system is broken down into four components. The first digit indicates the region of the body that was injured.

1 External area
2 Head
3 Face
4 Neck
5 Thorax
6 Abdomen and pelvic contents
7 Spine (includes cervical spine)
8 Upper extremity
9 Lower extremity

The second and third digits identify the organ or more specific site within a body region.

The fourth and fifth digits denote the succession of injury severity within each organ or body region, generally starting with *not further specified* (NFS). A decimal point is placed between the fifth and sixth digits.

The sixth digit denotes the AIS code for the level of the severity of the injury. The maximum injury is that designated as virtually unsurvivable under the standards of AIS 85 (*2*). The severity codes are

.1 Minor
.2 Moderate
.3 Serious
.4 Severe
.5 Critical
.6 Maximum (virtually unsurvivable)
.9 Unknown

Two examples of injury coding employing these codes are shown in figure 1. In the examples shown, the digits are separated into components for clarity.

External area coding. The major exception to this coding structure is the body area designated under AIS 85 as *external*.

For such injuries, the first digit, a one, identifies the injury as external.

The second and third digits denote the type of injury.

01 Abrasion
02 Contusion

Figure 1. Examples of standard AIS 85 injury coding

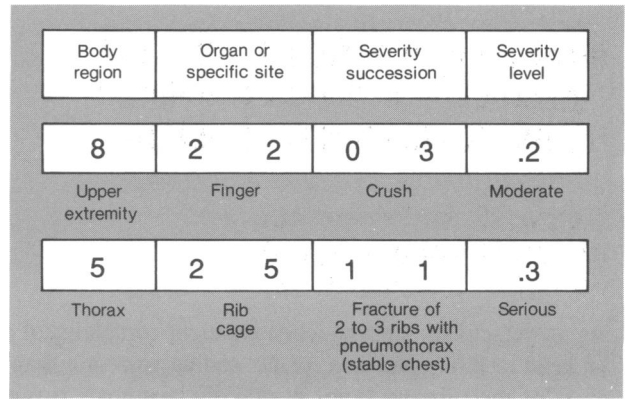
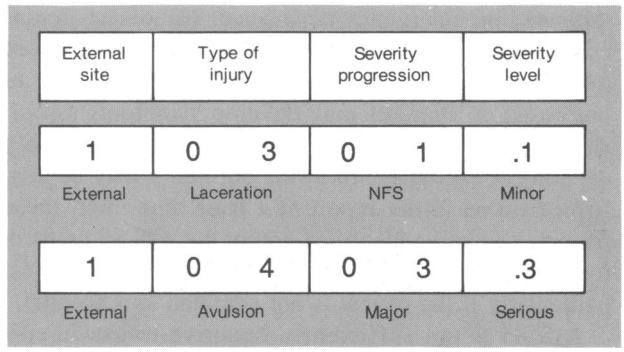


Figure 2. Examples of standard AIS 85 injury coding for the external area



03 Laceration
04 Avulsion (tearing away of a part)
05 Penetrating injury
06 Degloving injury (removal of the skin surface)
07 Burn

The fourth and fifth digits describe the order of succession of severity for each injury designation.

Following the decimal place, the sixth digit denotes the AIS severity code for the injury.

Two examples of AIS 85 injury coding employing codes for the external region are shown in figure 2.

AIS 85 incorporates a one-page foldout of a condensed AIS chart that lists all injuries described in the text and their severity level. The condensed list is similar in concept to the single-page computerized approach developed for AIS 80, which assigned a unique descriptor code to each defined AIS injury (*9*).

AIS 85 Limitations

Using AIS 85, external injuries are coded to the nonspecific category *external* because no coding method has been provided to describe the specific body region of such an injury. Neither is there a provision for cod-

'This approach facilitates coding such information while still allowing investigators who choose to do so to include only documented anatomic injuries in their analyses without any changes in the basic AIS coding structure.'

ing a contact site, such as when a patient complains of a hit head or a bumped arm, or for coding pain or a diagnosis of the rule out type. A rule out diagnosis is one that specifies possible, but currently unverified, injuries that later may be shown to be present.

Possible, or rule out injury, contact, or pain often are indicated on emergency department records as an outcome of an injury producing event in the absence of other indications of injury to a specific anatomic site or body region. Patients may develop symptoms associated with the contact or pain after the initial emergency department encounter, or a rule out injury may be confirmed on an X-ray report at a later time. Yet, these patients cannot be identified within the AIS 85 protocol for such purposes as followup in epidemiologic studies, particularly if the patient is not admitted to a hospital.

AIS 85 is not sufficiently sensitive to use in epidemiologic studies designed to measure shifts in patterns of injury severity or location. Examples are those involving a range of injuries from serious to minor, from skull fracture to scalp abrasion, or body contact without documented injury. Neither is it sufficiently sensitive to determine changes at the same severity level within and among body regions, especially when evaluating the before and after effects of intervention strategies.

AIS 85-EM Modifications

Because of these limitations, a modification to enhance the sensitivity and specificity of AIS, called AIS 85-EM (Epidemiologic Modifications), was developed by Brookhaven National Laboratory's Injury Prevention and Analysis Group (IPAG). AIS 85-EM is described in the group's AIS Training Manual of May 1989 (*10*). IPAG has conducted training sessions in the use of AIS 85-EM for various agencies, including the State of New York Department of Health's Injury Control Unit.

AIS 85-EM was developed to use in coding data on anatomic injury type and location useful for epidemiologic and evaluation purposes. The data generally are available in hospital emergency department and admission records, but are not codable by the standard AIS 85 protocol.

Our primary criterion in modifying AIS 85 was to be consistent with its original structure, whose format allowed sufficient flexibility to accommodate coding for site-specific external injuries, pain, and bodily contact, without changing the basic AIS 85 structure.

In the coding for the external region, the second digit, always a zero in AIS 85, is used in AIS 85-EM to designate body regions. For example, a laceration (NFS) under AIS 85 is coded

10301.1

and an abrasion NFS is coded

10101.1

regardless of the body region involved. Under AIS 85-EM, body region codes 2 through 9 are substituted for the zero second digit. Thus, a laceration of the head NFS is coded

12301.1

and a superficial arm abrasion is coded

18102.1

In AIS 85, the forehead is classified under the body region *face*. Since an injury to the forehead can result in a concussion or other brain injury, the forehead should be identified as a specific site within a body region. Since the fourth digit in the AIS *external* code also is zero, when using AIS 85-EM, an external injury of the forehead is identified by replacing the second decimal place zero with the numeral 3, indicating *face*, and the fourth decimal place zero with the numeral 2, indicating *head*. With this modification, a major contusion of the forehead is coded

13223.2

In AIS 85 it is

10203.2

An injury to *side* is sometimes entered in a hospital emergency department record. *Side* is not *thorax* or *abdomen*, but part of both. The combination 56 is assigned to the anatomic site *side*, with the numeral 5 in the second zero place to indicate thorax and the numeral 6 in the fourth zero place to indicate abdominal and pelvic regions. By this modification, an abrasion to the side NFS is coded

15161.1

AIS 85-EM allows coding a statement on a hospital record regarding a possible injury, bodily contact, or pain, by assigning the values .7, .8, or .9 in the sixth

digit place. The values are not severity level indicators and are not included in severity analyses; instead, they are used as flags to indicate that an injury may have occurred, but that no severity can be assigned at that time. If an anatomic injury is verified at a later date, the appropriate AIS code and severity level can replace them.

Using AIS 85-EM, a diagnosis on an emergency room record that is recorded as rule out, possible, probable, or questionable is assigned the AIS 85 five-digit numeric value that designates the injury, followed by the numeral .8 in the severity level position to designate *rule out*. Using this procedure, a rib fracture NFS is coded

52502.1

which is standard AIS 85 protocol. Rule out rib fracture becomes

52502.8

In AIS 85-EM, cerebral concussion is

20637.2

and a possible concussion is

20637.8

If an injury is verified at a later time, the actual injury code would replace the rule out code.

If contact with an object is noted for an AIS classification of body region with no documentation of injury or pain, the first digit is assigned to the body region, followed by 0000.9 to designate contact without evidence of injury. To identify pain in the absence of documented anatomic injury, the AIS body region code is assigned in the first digit position, followed by 0000 and .7 to denote pain. Therefore, head pain becomes

20000.7

neck pain becomes

40000.7

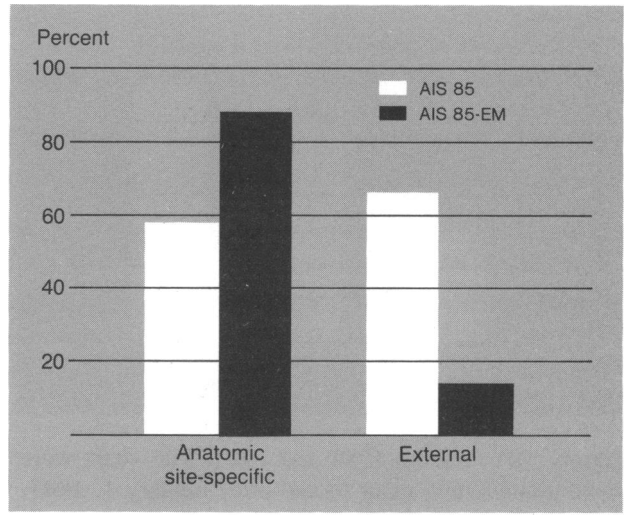
and leg contact becomes

90000.9

Again, if an injury is verified at a later time, such as a nose hit on a steering wheel, subsequently diagnosed as a nasal fracture, or neck pain is later diagnosed as a cervical strain, the contact or pain code can be replaced with the actual AIS injury code.

If there is a complaint of contact with or pain in the forehead region with no other head injury mentioned, the first digit is assigned the AIS code for body region 3 to designate *face*, and the second digit AIS body region 2 to designate *head*. Thus, forehead contact without

Figure 3. Percent of 3,223 trauma cases coded with specific anatomic site of injury, and site not specified, using AIS 85 and AIS 85–EM



mention of injury is

32000.9

and forehead pain in the absence of documented injury is

32000.7

A complaint of contact with the side is assigned code

56000.9

and side pain is coded

56000.7

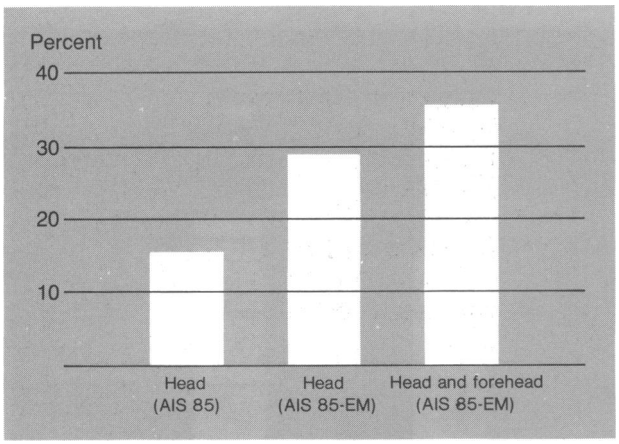
The AIS 85-EM coding for contact and pain is

Body region	*Contact*	*Pain*
External	10000.9	10000.7
Head	20000.9	20000.7
Face	30000.9	30000.7
Forehead	32000.9	32000.7
Neck	40000.9	40000.7
Thorax	50000.9	50000.7
Side	56000.9	56000.7
Abdomen and pelvic contents	60000.9	60000.7
Spine	70000.9	70000.7
Upper extremities	80000.9	80000.7
Lower extremities	90000.9	90000.7

Results

To measure changes in sensitivity and specificity of AIS 85-EM from AIS 85, hospital records of 3,223 motor vehicle trauma patients were reviewed. The records were for a population-representative sample of all motor vehicle trauma patients treated in the acute care hospitals with emergency departments serving Suffolk

Figure 4. Percent of 3,223 trauma cases coded with one or more identified head injuries, using AIS 85 and AIS 85–EM



County, NY, during 1984 and 1985. The years were those immediately prior to and after January 1, 1985, when enforcement of New York's seatbelt law began (*11, 12*).

Each injury was coded using standard AIS 85 and independently recoded using AIS 85-EM. Using standard AIS 85, 68 percent of the patients were classified as having one or more injuries coded for the nonspecific *external* region. Using AIS 85-EM, only 15 percent of the cases were patients with injuries that could not be coded for a specific anatomic site (figure 3). Such injuries were listed on emergency department records as lacerations, contusions, or abrasions without reference to a body region.

The proportion of patients with documented head injuries increased from 16 to 30 percent using AIS 85-EM. The proportion increased to 37 percent when forehead injuries were included (figure 4).

Fifty percent of the patients had complaints of pain to a site in a body region without documented injury, and 4 percent reported contact to a site without complaint of injury or pain. Of these, about two-thirds reported contact of the head or forehead. Seven percent of the patients had rule out type diagnoses; 61 percent of the rule out diagnoses were possible head injuries, for example, rule out concussion.

When using AIS 85-EM to code documented external injuries, large increases were observed in anatomic site specificity for all body regions. There were further notable increases when rule out, contact, and pain codes were included (figure 5).

Discussion

The need to modify AIS 85 became apparent while we were conducting a population-based study of motor vehicle trauma (*11, 12*). Considerable detail regarding an injury event, such as anatomic site specificity for external injuries and statements of bodily contact or pain, were available from emergency department records, but could not be coded using AIS 85.

The capability to code data routinely available on medical records, such as body region specificity for external injuries, rule out type statements, contact, and pain, furthers epidemiologic, engineering, research, evaluation, and followup efforts and allows the best use of the information. Abstracting and coding such information reduces subsequent abstracting and coding decision making regarding what information is important.

This approach facilitates coding such information while still allowing those investigators who choose to do so to include only documented anatomic injuries in their analyses without any changes in the basic AIS coding structure. Because the rule out, contact, and pain designations are not injury or severity level indicators, investigators can code such statements in the absence of documented injury, without including the codes for severity analyses. If a statement regarding a potential injury is subsequently verified as an actual injury, such as head contact that may be diagnosed later as a concussion, the appropriate AIS 85 code and severity level can be reassigned.

The ability to code a rule out type statement is important because rule outs or a possible injury are often entered on a hospital record pending injury verification by later X-ray, nuclear scan, or magnetic resonance imaging. The flagging system for rule out injuries allows investigators to follow those cases requiring verification.

The rule out issue is of particular concern because medical records procedures regarding rule out coding may vary within and among institutions. Some institutions and medical record professionals view rule out as a confirmed diagnosis and others as the opposite. This may account for some of the differences observed by other investigators who have examined the issue of AIS coding variability (*9, 13, 14*).

From engineering and epidemiologic perspectives, the ability to code information regarding bodily contact is important for evaluating before- and after-injury intervention strategies and for understanding injury mechanisms (*1*). For engineering purposes in particular, knowledge of body contact points, with or without injury, can play a key role in biomechanical analyses and the design of systems to protect persons from injury.

While pain is the most subjective symptom addressed in AIS 85-EM, pain may be indicative of an injury that does not manifest itself until after the patient is discharged from the emergency department. This enables researchers to obtain additional information potentially

important for followup purposes without compromising the basic AIS 85 coding structure.

Since no injury severity code (AIS severity designations 1 through 6) is assigned to rule out, contact, or pain, investigators can ignore these codes when analyzing injury severity, while still recognizing that these outcomes of an injury-producing event may be significant in themselves. By permitting coding of these documented statements on medical records, bias such as variations in abstractor or coder decision making, demonstrated in some of the studies using AIS to identify cause-specific injury, could be avoided (*9, 13, 14*).

Improving specificity when identifying and classifying an injury by AIS is particularly important for epidemiologic research. It is critical to measuring injury outcome before and after an intervention strategy is initiated to identify changes in injury patterns and to evaluate the effectiveness of preventive measures. It is especially important when determining the efficacy of injury countermeasure programs that are more likely to alter severity rather than incidence patterns, or when identifying changes in injury patterns within and among body regions.

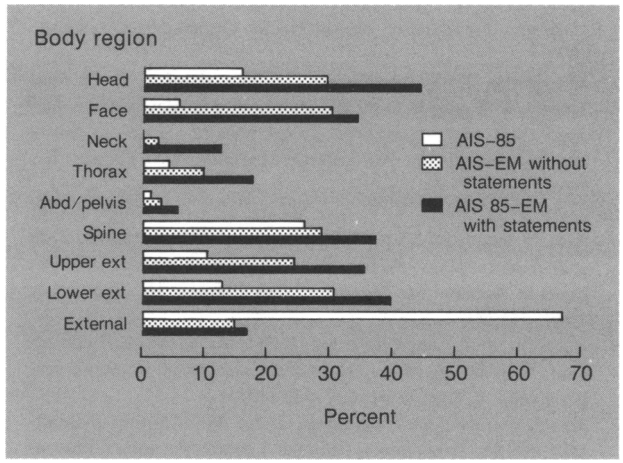
The modifications presented as AIS 85-EM are straightforward and can be incorporated into the standard AIS coding system without changing its basic structure. When anatomic site is specified in a medical record, data obtained from AIS 85-EM, compared to the standard AIS 85 version, suggest that whenever possible, site-specific coding of all injuries is needed to draw valid and reliable inferences about intervention strategies. In our analysis, using AIS 85-EM, diagnoses coded to the nonspecific *external* category decreased by a factor of four (figure 3), and codable head injuries nearly doubled (figure 4).

Case determination of *threshold brain injury* is important for measuring the incidence of concussion and the proportion of cases with possible postconcussive syndrome. The data suggest that the incidence of concussion is substantially underreported. From a public health perspective, the sequelae of minor head injuries can have major long-term implications (*15*).

When AIS 85 was used exclusively, 16 percent of the injury cases were identified as sustaining a head injury. More than one-half of the cases were identified as a possible head injury when we considered external injuries to the head, all forehead injuries, and head or forehead rule out injuries, contact, or pain. If AIS 85-EM had not been used, potential cases of threshold brain injury, such as concussion, could have been underreported by nearly 70 percent.

AIS 85-EM improves the sensitivity and specificity in coding anatomic injuries critical to assessing the effectiveness of interventions, such as safety belt laws.

Figure 5. Percent of 3,223 trauma cases coded with injury to a body region using AIS 85 and AIS 85–EM, without and with the rule out, pain, and contact statements



NOTE: Forehead included in face category.

The head injury underreporting issue is applicable to seat belt use patterns before and after laws are promulgated, as well as all aspects of the trauma cycle, preevent, event, and postevent.

Our findings suggest the need to convert existing data bases, those that have used standard AIS 85, to AIS 85-EM in order to further enhance our knowledge of the frequency, severity, and outcome of site-specific anatomic injury. We need to consider incorporating the epidemiologic modifications into subsequent versions of AIS to enhance its usefulness for research and evaluation purposes.

Quantitative and qualitative information about injury severity patterns, shifts in patterns, and sequelae need to be made available to decision makers in the public and private sectors so they can evaluate better the effectiveness of specific countermeasure programs. More generally, this type of comprehensive injury information is needed for efficacious public health policy and programmatic decision making.

References

1. States, J.: Problem delineation: automobile restraint systems. Bulletin, New York Academy of Medicine, September-October 1988.
2. American Association for Automotive Medicine: The abbreviated injury scale. 1985 Revision. Arlington Heights, IL.
3. Baker, S. P., O'Neill, B., Haddon, W., Jr., and Long, W. B.: The injury severity score: A method for describing patients with multiple injuries and evaluating emergency care. J Trauma 14: 187–196 (1974).
4. MacKenzie, E. J., Shapiro, S., and Eastham, J. N.: Rating AIS severity using emergency department sheet vs. inpatient charts. J Trauma 25: 984–988 (1985).
5. Petrucelli, E., States, J. D., and Hames, L. N.: The abbreviated

injury scale: evolution, usage, and future adaptability, Accid Anal Prev 13: 29–35 (1981).
6. International classification of diseases: manual of the international statistical classification of diseases, injuries, and causes of death. 9th revision. World Health Organization, Geneva, 1977.
7. MacKenzie, E. J., Steinwachs, D. M., Shankar, B. S., and Turney, S. Z.: An ICD-9CM conversion table: development and application. 30th annual proceedings, Montreal, Quebec. American Association for Automotive Medicine, Des Plaines, IL, 1986, pp. 135–151.
8. Civil, I. D., Streat, S. J., and Judson, J. A.: A comparison of AIS 85 with AIS 80 for injury scaling in blunt trauma. 38th annual proceedings, Seattle, WA. Association for the Advancement of Automotive Medicine, Des Plaines, IL, September 1988, pp. 145–155.
9. Barancik, J. I., and Chatterjee, B. F.: Methodological considerations in the use of the abbreviated injury scale in trauma epidemiology. J Trauma 21: 627–631 (1981).
10. Kramer, C. F., and Barancik, J. I.: AIS training manual. BNL-52184. Brookhaven National Laboratory, Injury Prevention and Analysis Group, Upton, NY, May 1989.
11. Barancik, J. I., Kramer, C. F., and Thode, H. C., Jr.: Efficacy of the New York State seat belt law: preliminary assessment of occurrence and severity. Bulletin, New York Academy of Medicine, September-October 1988.
12. Barancik, J. I., Kramer, C. F., Thode, H. C., Jr.: Epidemiology of motor vehicle injuries in Suffolk County, N.Y., before and after enactment of the New York State seat belt use law. Final report submitted to the U.S. Department of Transportation, National Highway Traffic Safety Administration, June 1989.
13. MacKenzie, E., Shapiro, S., and Eastham, J.: The abbreviated injury scale and injury severity score: levels of inter- and intrarater reliability. Med Care 23: 823–835, June 1985.
14. Tepas, J. J., et al.: Inter-rater reliability of the injury severity score and abbreviated injury score. 33nd annual proceedings, Baltimore, MD. Association for the Advancement of Automotive Medicine, Des Plaines, IL, October 1989, pp. 183–190.
15. Ommaya, A. K.: Mechanisms and preventive management of head injuries: a paradigm for injury control. George G. Snively memorial lecture, 32nd annual proceedings, Seattle, WA. Association for the Advancement of Automotive Medicine, Des Plaines, IL, September 1988, pp. 360–391.

Pregnancy and Medical Cost Outcomes of a Self-Help Prenatal Smoking Cessation Program in a HMO

DANIEL H. ERSHOFF, DrPH
VIRGINIA P. QUINN, MPH
PATRICIA DOLAN MULLEN, DrPH
DAVID R. LAIRSON, PhD

Dr. Ershoff is President and Ms. Quinn is Associate Director, Maxicare Research and Educational Foundation, Los Angeles. Dr. Mullen is Associate Professor, School of Public Health, and Associate Director, Center for Health Promotion Research and Development, and Dr. Lairson is Associate Professor, School of Public Health, University of Texas Health Science Center, Houston.

This project was funded by grant No. HSO5128 from the National Center for Health Services Research and Maxicare Health Plans, Inc. Tearsheet requests to Daniel H. Ershoff, DrPH, Maxicare Research and Educational Foundation, Rm. 382, 12021 Wilshire Blvd., Los Angeles, CA 90025.

Synopsis

The results of a randomized clinical trial of a prenatal self-help smoking cessation program are reported in terms of the pregnancy and cost outcomes. The study population were the socioeconomically and ethnically diverse members of a large health maintenance organization (HMO) who reported that they were smoking at the time of their first prenatal visit.

The intervention consisted predominately of printed materials received through the mail. Compared with the usual care control group, women assigned to the self-help program were more likely to achieve cessation for the majority of their pregnancy (22.2 percent versus 8.6 percent), gave birth to infants weighing on average 57 grams more, and were 45 percent less likely to deliver a low birth weight infant.

An economic evaluation of the self-help program was conducted from the perspective of the sponsoring HMO. Based upon the expenditures associated with the neonates' initial hospital episode, the intervention had a benefit-cost ratio of 2.8:1. These findings provide strong evidence to support widespread incorporation of smoking cessation interventions as a standard component of prenatal care.

INTRAPREGNANCY SMOKING is associated with intrauterine growth retardation (IUGR), shortened gestation, and perinatal morbidity and mortality (*1*). Women who smoke during pregnancy have from two to four times the chance of delivering a growth retarded infant, with a 32–45 percent absolute risk of IUGR resulting from smoking (*2*). Prematurity rates are nearly 50 percent higher for smokers, and 11–14 percent of all preterm