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ARTICLE

School Bus–Related Injuries Among Children and Teenagers in the United States, 2001-2003

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ABSTRACT

OBJECTIVE. The purpose of this work was to describe the epidemiology of nonfatal school bus–related injuries among children and teenagers aged ≤19 years in the United States.

DESIGN/METHODS. Nationally representative data from the National Electronic Injury Surveillance System All-Injury Program operated by the US Consumer Product Safety Commission were analyzed. Case subjects included all of the patients in the National Electronic Injury Surveillance System All-Injury Program database who were treated in a hospital emergency department for a nonfatal school bus–related injury from 2001 to 2003.

RESULTS. There were an estimated 51 100 school bus–related injuries treated in US emergency departments from 2001 to 2003, for a national estimate of 17 000 injuries (rate: 21.0 per 100 000 population) annually. Ninety-seven percent of children were treated and released from the hospital. Children 10 to 14 years of age accounted for the greatest proportion of injuries (43.0%; rate: 34.7) compared with all other age groups. Motor vehicle crashes accounted for 42.3% of all injuries, followed by injuries that occurred as the child was boarding/alighting/approaching the bus (23.8%). Head injuries accounted for more than half (52.1%) of all injuries among children <10 years of age, whereas lower extremity injuries predominated among children 10 to 19 years of age (25.5%). Strains and sprains accounted for the highest percentage of all injuries, followed by contusions and abrasions (28.3%) and lacerations (14.9%). More than three quarters (77.7%) of lacerations were to the head.

CONCLUSIONS. This is the first study to describe nonfatal school bus–related injuries to US children and teenagers treated in US hospital emergency departments using a national sample. This study identified a much greater annual number of school bus–related injuries to children than reported previously.

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The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

Key Words
school bus, injury, traffic crash, transportation, trauma

Abbreviations
NHTSA—National Highway Traffic Safety Administration
ED— emergency department
NEISS—National Electronic Injury Surveillance System
AIP—All Injury Program
TRB—Transportation Research Board
NTSB—National Transportation Safety Board

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EACH YEAR IN the United States, 23.5 million children travel 4.3 billion miles on 450 000 school buses.[1] The National Highway Traffic Safety Administration (NHTSA) is the US government agency responsible for establishing the safety standards for school buses. The current standard requires school buses ≤10 000 lb gross vehicle weight rating to provide lap belts in all seating positions, whereas school buses >10 000 lb gross vehicle weight rating provide passive protection to passengers in the form of "compartmentalization."[2] Compartmentalization requires that school buses have closely spaced seats and high, padded seat backs.

According to the Transportation Research Board, there are 800 fatalities to school-aged children annually because of motor vehicle crashes during normal school travel hours, of which ~2% can be attributed to school bus–related crashes, including both passenger and pedestrian-related fatalities.[3] Similarly, an estimated 152 000 children are injured in motor vehicle crashes during school travel hours, of which 4% (6000) are school bus–related, including school bus passengers and pedestrians. These estimates are based on traffic crash data from the Nationwide Personal Transportation Survey, Fatality Analysis Reporting System, and the National Automotive Sampling System General Estimates System. NHTSA estimates that there are 8500 total school bus–related injuries per year, of which 86% are minor, 10% are moderate, and 4% are severe.[2] Fatal school bus–related events often occur outside the bus (pedestrian, bicyclist, or occupant of other vehicle), whereas nonfatal injuries frequently occur to passengers riding in the school bus.[3]

Motor vehicle crashes are a common and well-described mechanism of school bus–related injury; however, there is little information about other mechanisms of school bus–related injury or the types of injuries sustained while riding the school bus. This study is the first to provide national estimates of children and teenagers with nonfatal school bus–related injuries who were treated in US hospital emergency departments (EDs). Characteristics of injured persons, the type of injury, body region injured, common mechanisms of school bus–related injuries, and other selected factors are described.

METHODS

Nonfatal injury data for 2001–2003 used for this study were from the National Electronic Injury Surveillance System (NEISS) All Injury Program (AIP). NEISS is an ED surveillance system operated by the US Consumer Product Safety Commission since 1978. It was designed to collect information on consumer product–related injuries and to generate national estimates of these injuries. NEISS is a nationally representative, stratified probability sample of 99 hospitals in the United States and its territories that have ≥6 beds and provide 24-hour emergency care. The hospitals are stratified into 4 categories based on the annual number of ED visits (small, medium, large, or extra large), with an additional fifth stratum for children's hospitals. NEISS-AIP is a nationally representative subsample of 66 of the 99 NEISS hospitals. In this subsample, data are collected on initial visits for all types of injuries treated in the EDs, regardless of external cause or consumer-product involvement. NEISS-AIP began in July 2000 and collects data on ~500 000 injury-related visits annually.[4–8] This study was approved by the Columbus Children's Research Institute Institutional Review Board.

The NEISS-AIP database includes information on patient's age, gender, race/ethnicity, primary body part injured, type of injury (principal diagnosis as determined by the attending physician), consumer product involved (eg, in this case, a motor vehicle), locale where the injury occurred, month of ED treatment, disposition at discharge from the ED, and a brief narrative describing the circumstances of the injury incident. All of the cases with school bus–related injuries were identified by first subsetting all of the cases involving motor vehicles and then reviewing the narratives while searching for the term "school bus."

School bus–related injury cases were defined as any nonfatal injury treated in a NEISS-AIP hospital ED for children and teenagers aged ≤19 years when the person was riding on, getting on, getting off, or standing near the bus at the time of injury. Cases were excluded if the child was struck by a bus as a pedestrian or bicycle rider or if the child was injured in a motor vehicle crash as a passenger in a vehicle other than the bus. Based on these case criteria, information from the NEISS narrative was used to generate a variable describing the mechanism of injury. These mutually exclusive mechanisms included: (1) traffic, crash-related: the child was injured as a passenger on a school bus as a result of a crash between the bus and another motor vehicle; (2) boarding/alighting: the child was injured while getting on or off a school bus; (3) traffic, noncrash-related: the child was injured as an occupant when a school bus driver applied the brakes or turned a sharp corner, but no crash was involved; (4) child slipped/fell: the child was injured because of a fall while on the school bus, and there was no indication of a motor vehicle crash or other traffic-related factors; this also includes slips/falls that occur when the bus is in motion, stopped, or the motion of the bus was unknown; and (5) other/unknown: the child was injured because of any other or unspecified mechanism.

Study results were based on weighted data for 939 cases identified as being treated for nonfatal school bus–related injuries in NEISS-AIP hospitals from 2001–2003. Confidence intervals for national nonfatal injury rates were calculated using a direct variance estimation procedure that accounted for the sample weights and complex sampling design of NEISS-AIP.[6] Rates were calcu-

lated using the US Census 2001–2003 bridged-race population estimates obtained from the National Center for Health Statistics.[9] Rate difference calculations were performed to examine any significant ($P < .05$) relationships for injury mechanism, body region injured, and injury type by age group.

RESULTS

An estimated 51 100 (range: 37 400–64 800) children and teenagers ages 0 to 19 years were treated for school bus–related injuries in US hospital EDs during the 3-year period 2001–2003, yielding an average of 17 000 annually. The overall rate for this estimate was 21 per 100 000 population. The distribution of injuries by age group, gender, and race is shown in Table 1. Girls accounted for just more than half (51.1%) of all injuries. Children 10 to 14 years of age had the highest annual rate of injury (34.7 of 100 000), followed by children 5 to 9 years of age (23.3 of 100 000) and children 15 to 19 years of age (21.4 of 100 000). Among those injured with recorded race/ethnicity, 46.3% were white, non-Hispanics, and 27.9% were black. Ninety-seven percent of children were treated and released from the hospital. The greatest percentage of school bus–related injuries were treated during the months of September/October (31.5%), followed by March/April (21.4%; Fig 1). The most common location of school bus–related injury was the street (63.5%), followed by the school (20.0%; Fig 2).

Injury Mechanism

Table 2 presents the estimated numbers and percentages of various characteristics of school bus–related injury, by children <10 years old and children and teenagers 10 to 19 years old. When both age groups were combined, traffic crashes were the most frequent (42.3%) mechanism of injury, followed by boarding/alighting (23.8%). Children 10 to 19 years old experienced a greater proportion of injury because of crashes (46.2%) and boarding/alighting (25.2%) compared with children <10 years of age (33.8% and 20.7%, respectively).

Body Region Injured

Figure 3 shows the proportion of injuries by primary body region injured. Overall, among children and teenagers aged ≤19 years, the head was the most frequent body region injured, accounting for >15 000 (29.5%) injuries, followed by the lower extremity (21.3%) and trunk (16.8%). The head accounted for the highest percentage (52.1%) of injuries among children 0 to 9 years old (Table 2), followed by lower extremity injuries (12.0%). Conversely, lower extremity injuries accounted for the highest percentage of injuries (25.5%) among children 10 to 19 years of age, which was significantly different from the 12.0% among children 0 to 9 years of age ($P < .001$).

Head injuries were most often related to traffic crashes (31.2%) and other/unknown factors (32.3%), whereas more than half (57.6%) of lower extremity injuries were related to boarding/alighting. Traffic crashes were also related to 83.8% of neck injuries.

Injury Diagnosis

Overall, among children and teenagers ≤19 years of age, strains and sprains accounted for the highest percentage of injuries (33.4%), followed by contusions and abra-

TABLE 1 Estimated Annual Number, Percentage, and Injury Rate Among Persons With Nonfatal School Bus–Related Injuries Treated in Hospital EDs According to Age, Gender, and Race, United States, 2001–2003

Variable	Annual No.[a]	%	Annual Rate[a]	(95% Confidence Interval)
N	17 033	100.0	21.0	(15.4–26.7)
Age, y				
0–4	702	4.1	[b]	[b]
5–9	4654	27.3	23.3	(15.9–30.7)
10–14	7316	43.0	34.7	(25.9–43.6)
15–19	4361	25.6	21.4	(13.7–29.2)
Gender				
Male	8326	48.9	20.1	(13.8–26.3)
Female	8707	51.1	22.1	(16.1–28.0)
Race				
White, non-Hispanic	7884	46.3	—	—
Black[c]	4744	27.9	—	—
Hispanic	1155	6.8	—	—
Other, non-Hispanic	570	3.3	—	—
Unknown	2680	15.7	—	—

— indicates rates not presented because a substantial percentage of cases had unknown race/ethnicity.

[a] Average annual number and rate per 100 000 population based on 3 years of study data.

[b] Estimates might be unstable because the coefficient of variation is >30% or the number of actual NEISS-AIP cases is <20.

[c] Includes Hispanic and non-Hispanic.

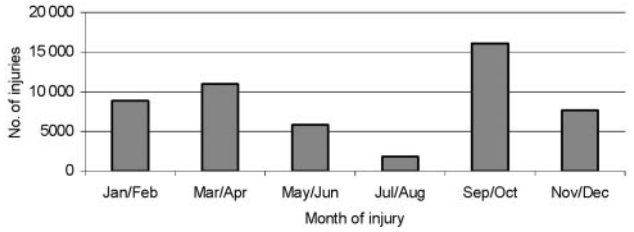

FIGURE 1
Estimated number of school bus–related injuries treated in hospital EDs according month of treatment, United States, 2001–2003.

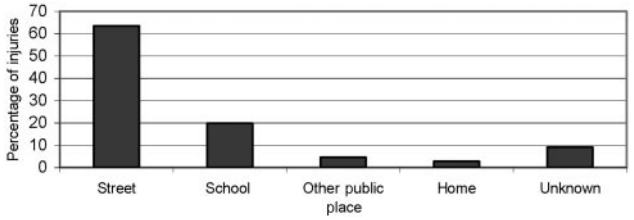

FIGURE 2
Percentage of school bus–related injuries treated in hospital EDs according to locale where the injury occurred, United States, 2001–2003.

sions (28.3%) and lacerations (14.9%). Strains and sprains occurred frequently in the neck (37.0%), lower extremity (33.2%), and trunk (21.2%). More than three quarters (77.7%) of lacerations were to the head. Children 0 to 9 years of age had a higher proportion of lacerations (29.8%) than children 10 to 19 years of age (8.0%); however, this difference was not statistically significant ($P = .14$; Table 2). Children ≥10 years of age sustained strains and sprains more frequently (42.1%) than children <10 years of age (14.5%), and this relationship was statistically significant ($P < .001$).

More than half of strains/sprains (56.7%) and traumatic brain injuries (56.1%) and 44.9% of contusions/abrasions were related to traffic crashes. Fractures were most often associated with boarding/alighting (42.0%) and other or unknown causes (37.4%). Lacerations were frequently related to boarding/alighting (20.6%) and other/unknown causes (46.9%)

DISCUSSION

The number of school bus–related injuries in this study greatly exceeded those published in previous reports, most likely because this analysis includes children injured in school buses regardless of the nature of the trip and hours traveled. According to Special Report 269 of the Transportation Research Board (TRB), there are an estimated 5500 school bus–related injuries per year to children as school bus passengers[3]; however, our study showed that there are an estimated 17 000 school bus–related injuries annually, >3 times that reported previously. The discrepancy in the data is because of differences in data collection. School bus–related injury data for the TRB study come from the National Automotive Sampling System General Estimates System, which contains data on traffic crashes that result in property damage, injury, or death. That data set does not include school bus–related injuries associated with other mechanisms. In addition, the TRB study captures only those school bus–related injuries that occur during the study-defined school travel hours (6:00 AM to 8:59 AM and 2:00 PM to 4:59 PM, Monday through Friday, from September 1 through mid-June). Our data captured school bus–related injuries occurring during any month of the year. These results support the conclusion of the National Transportation Safety Board (NTSB) that the reporting of school bus–related injury data in current national transportation data systems is incomplete and cannot be used to reliably estimate fatal and nonfatal school bus–related injuries.[3] Given the number of children who travel by school bus each year, the proportion of injured children requiring hospitalization (ie, ~3% of those treated in hospital EDs based on our study) is relatively low. However, there is a need for continuing vigilance to ensure that school buses remain a safe mode of transportation for children.

Children 10 to 14 years of age had the highest rate of school bus–related injuries treated in US hospital EDs during 2001–2003. Children in this age group may be more likely to ride the bus, because they are more independent than younger children, and their parents may not feel that they need to be transported by car. In addition, children ≥16 years of age may be more likely to drive themselves to school or ride with a friend who drives. Therefore, school bus safety messages may need to especially reach and affect children 10 to 14 years of age. The seasonal distribution of school bus–related injuries (Fig 1) was not surprising, because summer break and holiday vacation during the months of November and December would mean fewer days that children were riding the bus. In addition, the beginning of the school year may be marked with high student anxiety and excitement, more children riding the bus, and new bus drivers.

A motor vehicle crash was the most frequent injury mechanism for all of the age groups in this study. Although seat belts have the potential to influence some of the injuries in the 42.3% of cases involving motor vehicle crashes in this study, we were unable to determine whether seat belts would have prevented these motor vehicle crash–related injuries because of lack of sufficient detail in the narratives. This limitation also makes it difficult to estimate the impact that seat belts or other preventive strategies might have had on injuries from boarding/alighting, slip/fall, traffic noncrash events, or other/unknown mechanisms of injury.

NHTSA crash testing showed that school bus passengers were better protected from head injury with a lap/shoulder belt compared with compartmentalization and lap belts only.[1] Theoretically, a lap/shoulder restraint

TABLE 2 **Characteristics of School Bus–Related Injuries Treated in Hospital EDs According to Age Group, United States, 2001–2003**

Variable	0–9 y			10–19 y		
	N	%	(95% Confidence Interval)	*N*	%	(95% Confidence Interval)
Mechanism of injury						
Traffic, crash-related	1808	33.8	(16.2–51.3)	5398	46.2	(29.3–63.2)
Boarding/alighting	1109	20.7	(9.8–31.6)	2947	25.2	(18.5–32.0)
Slip/Fall	18	11.5	(6.2–16.9)	544	4.7[a]	[a]
Traffic, noncrash	316	5.9[a]	[a]	544	4.7	(2.0–7.4)
Other/unknown	1504	28.1	(16.6–39.6)	2245	19.2	(13.1–25.3)
Body region injured						
Head	2793	52.1	(30.0–75.3)	2238	19.2	(12.6–25.7)
Neck	460	8.6[a]	[a]	1960	16.8	(8.0–25.6)
Trunk	626	11.7	(5.8–17.6)	2230	19.1	(11.8–26.4)
Upper extremity	475	8.9[a]	[a]	2133	18.3	(12.6–23.9)
Lower extremity[b]	641	12.0	(6.4–17.6)	2983	25.5	(17.7–33.4)
Other/not stated	361	6.7[a]	[a]	132	1.1[a]	[a]
Injury diagnosis						
Contusion/abrasion	1518	28.3	(16.7–39.9)	3306	28.4	(20.6–36.0)
Strain/sprain[b]	778	14.5	(6.2–22.8)	4918	42.1	(26.0–58.2)
Fracture	332	6.2[a]	[a]	948	8.1	(4.9–11.3)
Laceration	1593	29.8	(13.7–45.8)	936	8.0	(4.5–11.6)
Traumatic brain injury[c]	470	8.8	(4.4–13.1)	830	7.1	(4.2–10.0)
Other/not stated	665	12.4[a]	[a]	740	6.3[a]	[a]
Total	5356	100.0		11 677	100.0	

[a] Estimates might be unstable because the coefficient of variation is >30% or the number of actual NEISS-AIP cases is <20.
[b] $P < .001$.
[c] Includes concussions and internal head injuries.

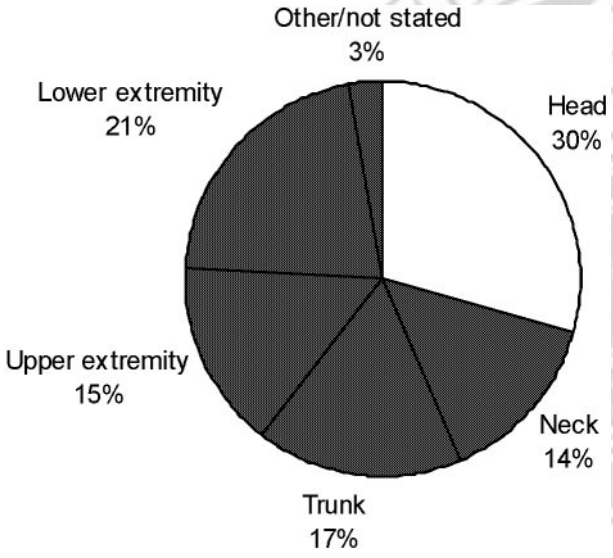

FIGURE 3
Percentage of school bus–related injuries treated in hospital EDs according to primary body region injured, United States, 2001–2003.

system would provide protection for crash-related injuries in school buses similar to that in other motor vehicles. Children would be kept in position during a crash, decreasing head impact during front or rear impact crashes, as well as securing children in the seat during lateral impacts and rollover crashes. Lap/shoulder systems may also provide protection in noncrash events, such as sudden turns and stops, by restraining children in their seats. The NTSB study of school bus crashworthiness found that compartmentalization provided incomplete protection to passengers during rollover crashes and lateral impact crashes.[10] The NTSB further recommends the development and implementation of a seat and restraint system that restrains passengers in the seating compartment, as well as the development of performance standards and requirements for school bus occupant protection systems on newly manufactured school buses.[10] Based on these and other studies, the American Academy of Pediatrics recommends that seat belts be installed on all newly purchased school buses.[11] This recommendation is based on findings of the NTSB and NHTSA school bus crash studies, as well as the recognition that improved student bus passenger behavior, reduced bus driver distraction, and the reinforcement of seat belt use among youth while riding in all motor vehicles may be additional benefits.[3,10,12,13]

Supervision can also play a role in reducing school bus–related injuries. The American Academy of Pediatrics recommends that supervision focus on keeping children seated, ensuring the use of seatbelts when available, and ensuring safe behavior while riding the bus. This would best be accomplished with an adult other than the bus driver on the bus.[11] The presence of a second adult on the school bus may also prevent driver distraction by providing a monitor to supervise passengers and allowing the driver to focus on the road. Supervision may also play an important role in reducing boarding and alighting injuries; helping to maintain

crowd control, pushing, and shoving; and assuring safe embarkment and disembarkment.

There were age-specific injury patterns regarding the body region injured. Younger children (<10 years) experienced a far greater proportion of head injuries than older children. In fact, head injuries accounted for more than half of all injuries to children <10 years of age. Young children, because of their anatomic characteristics, tend to topple head first during a fall, because of their high center of gravity. Combined with less strength and coordination of the upper extremities to help protect the head, this may explain the increased proportion of head injuries among younger children. These factors may also contribute to head injuries that occur during a motor vehicle crash, when a child's head strikes the seat in front of him/her, the window to the side, or other object if the child is thrown from his/her seat. The lower extremity was the most common body region injured among children 10 to 19 years old, and similar proportions of injuries occurred in all other body regions for this age group. Although most injuries were attributed to motor vehicle crashes and boarding/alighting, there were a large proportion of unknown mechanisms in both age groups. The large proportion of unknown injury mechanisms indicates that improved reporting of school bus–related injuries is needed.

There were also age group-specific injury patterns for the type of injury. More than 40% of injuries to children 10 to 19 years of age were sprains and strains, whereas a laceration was the most frequent diagnosis (30%) among children <10 years old. The high proportion of lacerations among young children (<10 years of age) is explained by the large number of head injuries in this age group. More than half of all injuries to children <10 years of age were to the head, and more than three quarters of all lacerations were to the head.

This study has several limitations. First, exposure data, such as the number of hours children spend on a school bus, were unavailable. Therefore, a more accurate rate of school bus–related injuries could not be calculated, other than the rate using the age-specific population as the denominator. Second, this study may underestimate the actual number of school bus–related injuries, because it is likely that injuries associated with smaller buses or passenger vans used for school travel may not be reported as school bus–related. Third, the lack of consistent detail in the narrative section of the NEISS-AIP database regarding the mechanism of injury was a limitation. Lacking more detail on how the injuries were sustained limits the conclusions that can be drawn regarding the potential effectiveness of certain prevention strategies. Finally, cases in this study may not be representative of all school bus–related injuries, because only those injuries that were treated in an ED are reported. Many injuries are not treated in EDs but instead are treated by children's caregivers, at a private physician's office, at other non-ED health care facilities, or do not receive medical treatment at all.

CONCLUSIONS

This is the first study to describe nonfatal school bus–related injuries to US children and teenagers treated in hospital EDs using a national sample. The greater annual number of school bus–related injuries to children found in this study, compared with previous reports based on other surveillance and reporting systems, suggests that previous estimates were an undercount. The findings from this study indicate that motor vehicle crashes are the leading mechanism of nonfatal school bus–related injury for children in the United States. In addition, this study identified several other important mechanisms of school bus–related injury. Further research is needed to determine the relative contributions of structural and operational components of the school bus, supervision, and rider behavior to the occurrence of these injuries and the effectiveness of occupant restraint systems and other strategies to prevent these types of injuries. Research is also needed to further elucidate the factors leading to the observed age-specific injury patterns of school bus–related injuries.

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THE METABOLIC SYNDROME

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"There is an international dispute among the World Health Organization, the European Group for the Study of Insulin Resistance, and the National Cholesterol Education Program regarding the existence of the metabolic syndrome. This multi-authored book offers an excellent, balanced overview of current knowledge of the syndrome and its importance in current and perhaps future health care. The first chapter addresses the controversial issue of how to classify the metabolic syndrome according to clinical measures. In an assessment of the burden of the metabolic syndrome, the authors estimate that this syndrome affects 10 to 23 percent of the world's population. . . . The fact that pharmaceutical companies are now seeking approval for drugs specifically targeting treatment of the metabolic syndrome makes the condition a hot topic among scientific, political, and economic groups. This interest was emphasized in a recent discussion paper by the American Diabetes Association and the European Association for the Study of Diabetes in which several interesting questions were raised. First, is the metabolic syndrome indeed a syndrome, particularly given that the precise cause is unknown? Second, does its definition serve a useful purpose? Third, does the use of this term label (and medicalize) people unnecessarily? . . .*The Metabolic Syndrome* is an excellent collection of updated reviews, and it provides a valuable background for understanding many aspects of this fascinating cluster of risk factors. However, the book does not address the big question—that is, whether a diagnosis of the metabolic syndrome offers a better prediction of cardiovascular risk than do the risk charts that are based on the individual components of the syndrome. This mystery remains to be solved."

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