TRAUMATIC BRAIN INJURY & SPINAL CORD INJURY SURVEILLANCE PROJECT

FISCAL YEAR 2002 FINAL REPORT

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This project is located at the Kentucky Injury Prevention and Research Center and funded by the Kentucky Traumatic Brain Injury Trust Fund

FOR MORE INFORMATION

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INTRODUCTION

This report summarizes data on traumatic brain injuries (TBI), spinal cord injuries (SCI), and acquired brain injuries (ABI) in Kentucky in 1999. These injuries are a major source of morbidity and mortality in Kentucky, resulting in loss of productivity, use of medical resources, and human suffering. For this reason, there is a critical need to have a data-driven understanding of these injuries. Through probabilistic data linkage of three data sets and the abstraction of hundreds of hospital records, the staff at the Kentucky Injury Prevention and Research Center (KIPRC) has created complete TBI, SCI, and ABI data sets.

This report represents a first look at these data sets to identify patterns in causation, demographics, and other factors that affect the incidence, severity, and mortality associated with these injuries in 1999. Initial analyses of these data reveal that the elderly suffer these injuries at much higher rates than younger Kentuckians. In addition, the elderly are more likely to die from their injuries. Similarly, males were not only more likely to incur a TBI, SCI, or ABI; they were also more likely to die from TBI and ABI.

METHODS

Data Preparation

Three data sets were computer linked in this study:

- National Center for Health Statistics (NCHS) Kentucky Supplemental Death File
- Kentucky Hospital Discharge Data, or HDD (Uniform Billing-1992 [UB-92], Inpatient only)
- Level-I trauma data from the University of Kentucky Hospital, University of Louisville Hospital, Kosair Childrens' Hospital, and Tennessee state TBI registry (for Kentucky residents treated in Tennessee)

Before these data were linked, duplicate records were removed from the HDD, and formats for variables such as date, time, age, etc. were standardized. Dates of various formats (mm/dd/yy, yyyymmdd, etc.) were all reformatted to Julian dates (number of days elapsed since January 1, 4713 BCE). This makes comparing dates much easier, as Julian dates are whole numbers. Ages were reformatted to 3-digits (e.g. 001, 089, 101), gender was formatted to simply "M" and "F", and races were placed into one of three categories--white, black, and other/unknown. In this way the data were standardized, then copied to a text-only format for linkage.

To identify cases of TBI, ABI, and SCI, Microsoft FoxPro programs were written to search for the appropriate ICD-9 or ICD-10 codes within the diagnosis fields of the respective data sets. For example, to identify TBI in the HDD, a program was written which searched for the Centers for Disease Control (CDC)-recommended codes within all nine diagnosis fields of each record. If at least one field contained a TBI diagnosis code, that record was selected for subsequent linkage.

TBI Case Definition

The CDC have established standards for TBI case identification. The following International Classification of Diseases, 9th Revision (ICD-9) diagnosis codes (n-codes) were used for this study:

- Fracture of vault or base of skull: 800.0-801.9
- Other, unqualified, and multiple fractures of skull: 803.0-804.9
- Intracranial injury, including concussion, cerebral laceration, subdural hemorrhage, unspecified intracranial injury, etc: 850.0-854.1
- Head Injury, unspecified: 959.01

In addition to these codes, International Classification of Diseases, 10th Revision (ICD-10) codes were used to identify TBI in mortality data:

- Open wound of head: S01.0-S02.9
- Fracture of skull and facial bones: S02.0-S02.1, S02.3, S02.7-S02.9
- Intracranial injury: S06.0, S06.2-S06.9
- Crushing injury of head: S07.0-S07.1, S07.8-S07.9
- Other unspecified injuries of head: S09.7-S09.9
- Open wounds involving head with neck: T01.0
- Fractures involving head with neck: T02.0
- Crushing injuries involving head with neck: T04.0
- Injuries of brain and cranial nerve with injuries of nerves and spinal cord at neck level: T06.0
- Sequelae of injuries of head: T90.1-T90.2, T90.4-T90.5, T90.8-T90.9

SCI Case Definition

The CDC define SCI by the following ICD-9 diagnosis codes:

- Fracture of vertebral column with spinal cord injury: 806.0-806.9
- Spinal cord injury without evidence of spinal bone injury: 952.0-952.9

The following ICD-10 codes were used to identify SCI in NCHS death records:

- Fracture of neck: S12.0-S12.2, S12.7, S12.9
- Fracture of thoracic vertebra and thoracic spine: S22.0-S22.1
- Fracture of lumbar spine: S32.0, S32.7
- Injury of nerves and spinal cord at neck level: S14.0-S14.1
- Injury of nerves and spinal cord at thorax level: S24.0-S24.1
- Injury of nerves and lumbar spinal cord at abdomen, lower back, and pelvis level: S34.0-S34.1, S34.3
- Fracture of spine, level unspecified: T08
- Injury of nerves and spinal cord involving other multiple body regions: T06.1
- Injury of spinal cord, level unspecified: T09.3
- Sequelae of injury of spinal cord: T91.3

ABI Case Definition

In addition to CDC-defined TBI, there are many brain injuries that have non-traumatic etiologies; these are referred to in this report as acquired brain injuries, or "ABI". Because these diagnoses are not included in the CDC definition of TBI, they have been linked and analyzed separately. These conditions were also identified by ICD-9 diagnosis codes, as follows:

- Anoxia/Hypoxia: 348.1, 668.2, 669.4, 768.1, 768.5, 768.6, 768.9, 799.0, 994.1
- Allergy/Anaphylaxis: 995.0, 999.4, 999.5
- Acute Medical Clinical Incidents: 320.0-320.9, 321.0-321.8
- Toxic Substances: 964.2, 967.0-967.9, 968.0-968.9, 980.0-980.9, 985, 986, 988.0-988.2, 989.0, 994.1, 994.7, 995.4, 995.5, 997.0, 998.0

The following ICD-10 codes were used to identify ABI in NCHS death records:

- Anoxia/Hypoxia: G93.1, O29.2, O74.3, O75.4, O89.2, P20.1, P21.0, P21.1, P21.9, R09.0, T75.1
- Allergy/Anaphylaxis: T78.0, T78.2, T80.5, T80.6, T88.1, T88.6
- Acute Medical Clinical Incidents: G00.0, G00.1, G00.2, G00.3, G00.8, G01, G07, G02.0, G02.1, G02.8, G04.2, G04.8, G05.0, G05.1, G06.2
- Toxic Substances: G03.8, G03.9, G97.1, G97.2, G97.8, G97.9, N14.3, R29.1, T40.5, T41.0, T41.1, T41.2, T41.3, T41.4, T42.3, T42.4, T42.6, T42.7, T45.5, T49.0, T51.0, T51.1, T51.2, T51.3, T51.8, T51.9, T56.1, T56.2, T56.3, T56.4, T56.5, T56.6, T56.7, T56.8, T57.0, T57.2, T57.3, T57.8, T58, T60.4, T61.9, T62.0, T62.1, T62.2, T62.8, T62.8, T64, T65.0, T65.8, T65.9, T71, T81.1, T88.2, T88.5

Data Linkage

During the linkage process, the variables birth date, date of death, date of discharge, gender, age, race, county of residence, zip code of residence, and county of injury were considered for linkage variables. Not all were used for every linkage, however. Birth date, date of death/discharge, county of residence, and zip code of residence are the most discriminating variables, and therefore most valuable for linkage purposes. In many cases, a seldom-occurring birth date coupled with an equally seldom occurring zip code was enough to label a pair of records a match, by AUTOMATCH standards. AUTOMATCH generally recommends a 9-1 ratio of true-false matches. In most cases, the ratio used in this study was higher.

Data Abstraction

In fiscal year 2002, a medical records abstractor visited hospitals across the state to collect more information on TBI cases. About 120 hospitals were asked to participate, and more than 80% agreed. TBI records from the HDD were chosen for abstraction if they did not link to either of the other data sets. In addition, a 10% random sample of TBI records from the final linked data set was included in the abstraction. Only TBI records were abstracted in fiscal year 2002 due to delays in the data linkage process.

NCHS death data arrived much later than usual, most likely due to the switch to ICD-10 coding (ICD-10 coding is very different from ICD-9 coding).

Data were entered into a Microsoft Access data entry form on a laptop computer at the hospital, or were recorded on paper and entered into the computer at the office. In the latter case, the paper records were shredded after data entry. At no time during data abstraction were personal identifiers such as name, Social Security Number, street address, or telephone number collected.

The medical records abstractor collected (or attempted to collect) information on the following variables, if applicable:

- Blood Alcohol Concentration
- Toxicology/Drug Test results
- Seatbelt use
- Helmet use
- Work-relatedness
- Service referrals
- Time to return to work

In addition, the abstractor collected E-codes and any other data elements that may have been missing. Unfortunately, many of these data elements were often not present in the medical records. Information on service referrals and time to return to work was usually not present.

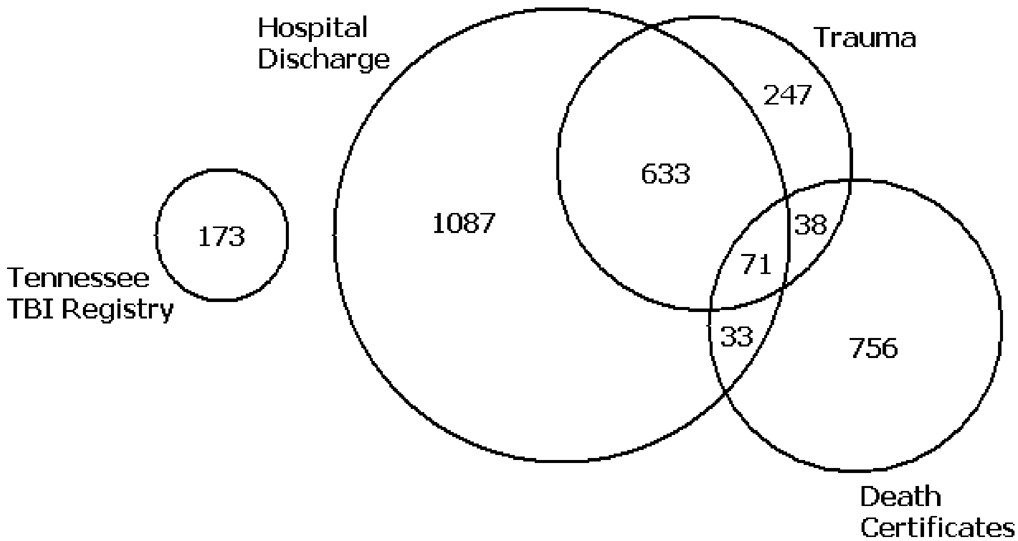
RESULTS—TBI IN KENTUCKY, 1999

After unduplication and linkage, the total number of TBI, SCI, and ABI cases was tabulated. Table 1 and the Venn diagram in Figure 1 show the number of TBI cases found only in a single data set, in two data sets, in all three, and also those provided by the Tennessee state TBI registry.

Table 1. Data sources and distribution of TBI among them, 1999

Data Source	Non-Fatal	Fatal	Total
HDD Inpatient Only	1069	18	1087
Trauma Only	233	14	247
NCHS Death Only	0	756	756
Trauma & HDD	625	8	633
Trauma & NCHS Death	0	38	38
HDD & NCHS Death	0	33	33
Trauma & NCHS Death & HDD	0	71	71
Tennessee Trauma Registry	151	22	173
Total	2078	960	3038

Figure 1. Data sources and TBI case distribution among them, 1999

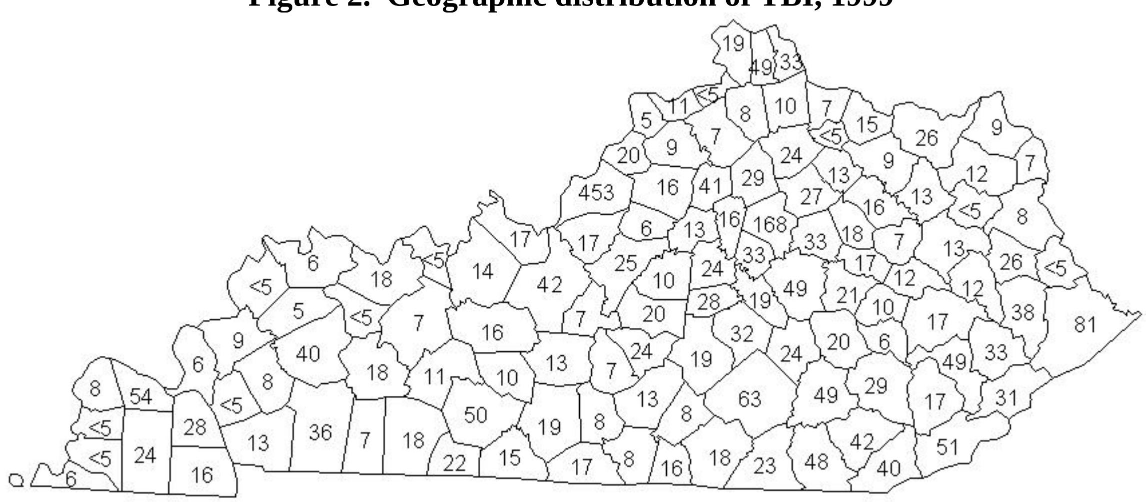


A total of 3038 cases of TBI were identified for calendar year 1999. This is many more than the 2457 identified for 1998, and is most likely due to fluctuations in the number of UB-92 hospital discharge records reported. The resulting incidence rate (IR) is 76.7 TBI per 100,000 residents in Kentucky.

<u>Geographic distribution of TBI</u>

Figure 2 displays the geographic distribution of TBI throughout Kentucky by the patients' counties of residence. In Jefferson County, 453 residents incurred a TBI, more than in any other county. Not surprisingly, Fayette County had the next largest number of TBI cases with 168. Other counties with fifty or more TBI in 1999 include Pike (81), Pulaski (63), McCracken (54), Harlan (51), and Warren (50). A complete list of all counties and their respective incidence rates is available in the Appendix (Table A-1).

Figure 2. Geographic distribution of TBI, 1999



TBI by Age, Gender

Table 2 lists the age and gender specific incidence rates per 100,000 Kentucky residents for TBI. Rates for females are generally much lower than those for males. (Note: All incidence rates in this report are reported per 100,000 residents)

Table 2. Age- and gender-specific incidence rates for TBI, 1999*

Age Range	Male Incidence Rate	Female Incidence Rate	Total Incidence Rate
0-4	36.1	19.8	28.2
5-14	36.9	25.0	31.1
15-24	149.8	61.6	106.6
25-44	123.2	38.7	80.2
45-64	86.9	28.3	56.5
65+	189.6	115.1	145.4
Total	107.6	47.5	76.7
*All incidence rates in this report are per 100,000 residents			

Table 3 displays the distribution of fatal and non-fatal TBI cases. A Mantel-Henzsel test for homogeneity of fatal and non-fatal cases among age groups reveals that some age groups are more likely to die from a TBI than others ($\chi^2 = 74.42$, $P < 0.0001$). Further analysis suggests that for each increase in age range, a person is more likely to die from a TBI (OR = 1.27, 95% confidence interval = 1.20-1.35).

Table 3. Fatal and non-fatal TBI by age, 1999

Age Range	Fatal	%	Non-Fatal	%	Total	%
0-4	5	0.5	69	3.3	74	2.4
5-14	22	2.3	144	6.9	166	5.5
15-24	164	17.1	451	21.7	615	20.2
25-44	308	32.1	641	30.9	949	31.2
45-64	184	19.2	333	16.0	517	17.0
65+	277	28.9	440	21.2	717	23.6
Total	960	100.0	2078	100.0	3038	100.0
Test for homogeneity $\chi^2 = 74.42$ ($P < 0.0001$) Test for trend $\chi^2 = 64.72$ ($P < 0.0001$)						

It should also be noted in Table 4 that fatal and non-fatal TBI are distributed unevenly among males and females ($\chi^2 = 38.38$, $P < 0.0001$). Simple univariate analysis reveals that males are more likely to die from a TBI than females (OR = 1.72, 95% confidence interval = 1.45-2.05).

Table 4. Fatal and non-fatal TBI by gender, 1999

Gender	Non-Fatal	%	Fatal	%	Total	%
Male	1341	64.5	728	75.8	2069	68.1
Female	736	35.4	232	24.2	968	31.9
Total*	2077	100.0	960	100.0	3037	100.0
χ^2 = 38.40 (P < 0.001) * There was also one case of unknown gender						

<u>Causes of TBI</u>

The major causes of TBI listed in Table 5 reflect perennial trends. Motor vehicle traffic accidents, falls, other transport accidents (referred to as "motor vehicle non-traffic accidents" in previous final reports), suicides, and homicides/assaults were again the major causes in 1999. Only 13% of cases had an unknown cause due to missing E-codes. Careful inspection of these figures will reveal that some causes (e.g. motor vehicle traffic accidents, homicides, suicides) have significantly greater fatality rates than others (χ^2 = 866.91, P < 0.001). These causes were homicide/assault (48.52% fatal), "Other accidents" (57.54% fatal), and suicides (98.00% fatal). Overall, 31.6% of cases resulted in a fatality.

Table 5. Major causes of TBI, 1999

Cause	Non-Fatal	%	Fatal	%	Total	%
Motor Vehicle Traffic Accident	681	32.8	318	33.1	999	32.9
Fall	399	19.2	91	9.5	490	16.1
Other Transport Accident	422	20.3	60	6.3	482	15.9
Other Accidents	107	5.2	145	15.1	252	8.3
Suicide	5	0.2	246	25.6	251	8.3
Homicide/Assault	87	4.2	82	8.5	169	5.6
Unknown	377	18.1	18	1.9	395	13.0
Total	2078	100.0	960	100.0	3038	100.0
χ^2 = 866.91, P < 0.001						

<u>Primary Payer</u>

Primary payers are listed in Table 6. Primary payer data were available for 1769 records in the HDD (97.0% of the 1824 records supplied by the HDD). Only 3% of records had an unknown primary payer, down from 15% in 1998 data. Commercial insurance was the most commonly listed primary payer for TBI cases in 1999, with 48.4% of cases. Commercial insurance patients represent 41.9% of fatalities. Medicare and Medicaid together accounted for 33.5% of all TBI primary payers, and these patients represent 39.6% of fatalities.

Table 6. Primary payers for TBI cases in HDD, 1999

Primary Payer	Non-Fatal	%	Fatal	%	Total	%
Commercial	802	48.9	54	41.9	856	48.4
Medicare	344	21.0	46	35.7	390	22.0
Medicaid	199	12.1	5	3.9	204	11.5
Other	166	10.1	24	18.6	190	10.7
Self Pay	64	3.9	0	0.0	64	3.6
Workers Comp	58	3.5	0	0.0	58	3.3
CHAMPUS	5	0.3	0	0.0	5	0.3
Other Federal Program	2	0.1	0	0.0	2	0.1
Total	1640	100.0	129	100.0	1769	100.0

Discharge Status

Table 7 lists the discharge status from the TBI cases in the HDD. Discharge status was present for virtually every HDD record, with less than 1% unknown. "Discharged Home" was the most common status—62.2% of all 1999 TBI cases. Other discharges that indicated continued need for some type of care (mostly inpatient care) accounted for 30.2% of cases.

Table 7. Discharge status of TBI cases in HDD, 1999

Discharge Status	Frequency	Percent
Discharged Home	1135	62.2
Discharged/Transferred to home under care of organized home health service organization	184	10.1
Discharged/Transferred to another type of institution for inpatient care or referred for outpatient services to another institution	170	9.3
Discharged/Transferred to skilled nursing facility	138	7.6
Expired	118	6.5
Discharged/Transferred to another short term general hospital for inpatient care	38	2.1
Left against medical advice or discontinued care	17	0.9
Discharged/Transferred to intermediate care facility	16	0.9
Still patient or expected to return for outpatient services	3	0.2
Other/Unknown	5	0.1
Total	1824	100

Length of Stay

Data on the length of hospital stay (LOS) was available for 2261 cases in the HDD and Trauma data. The mean, median, mode, and maximum LOS are listed in Table 8. The total number of days spent in the hospital, collectively, by TBI patients in 1999 was 22,225.

Table 8. Length of stay for TBI patients, 1999

Length of Stay	
# Cases	2261
Mean	9.8
Median	4
Mode	1
Maximum	373
Total	22,225

Work-Related TBI

Only 68 work-related TBI were identified for 1999. Fifty-nine of these were found in the HDD (if one of the payers was listed as “Workers Compensation”), and 9 were found via medical records abstraction. There were no fatalities among them.

RESULTS—SCI IN KENTUCKY, 1999

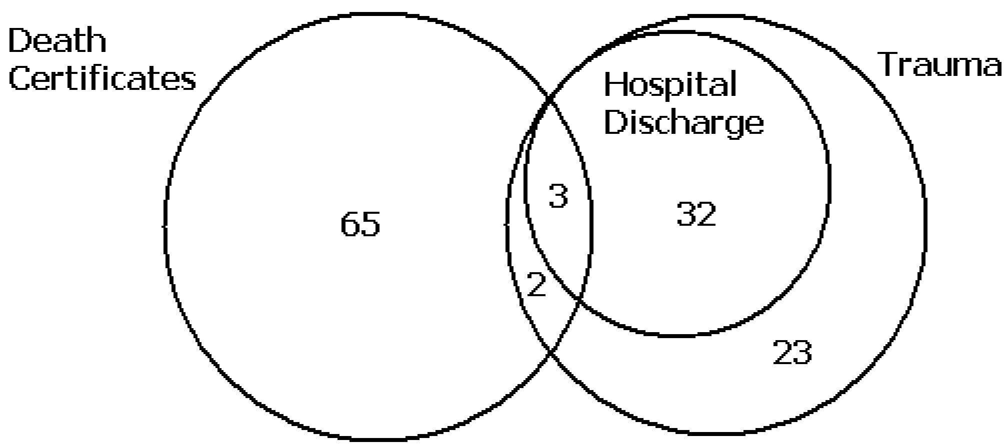
Table 9 and the Venn diagram in Figure 3 show the number of SCI cases found only in a single data set, in two data sets, or in all three.

Table 9. Data sources and distribution of SCI among them, 1999

Data Source	Non-Fatal	Fatal	Total
Trauma Only	23	0	23
Death Only	0	65	65
HDD & Trauma	32	0	32
Trauma & Death	0	2	2
HDD & Trauma & Death	0	3	3
Total	55	70	125

A total of 125 cases of SCI were identified for calendar year 1999. This is many fewer than the 162 identified for 1998. This number of cases results in an incidence rate of 3.16 SCI per 100,000 residents in Kentucky.

Figure 3. Data sources and SCI case distribution among them, 1999



Geographic distribution of SCI

Jefferson county had the most residents who suffered a SCI in 1999, with 21 total cases. Fayette county had 6 cases, and Campbell county had 5 cases. All other counties had 4 cases or fewer, if any. A complete list of Kentucky counties and their respective incidence rates is in the Appendix (Table A-2).

SCI by Age, Gender

Table 10 lists the age and gender specific incidence rates for SCI. Rates for females are generally much lower than those for males, and rates for 15-24 and 65+ age ranges for both genders are especially high.

Table 10. Age- and gender-specific incidence rates for SCI, 1999

Age Range	Male Incidence Rate	Female Incidence Rate	Total Incidence Rate
5-14	0.73	0.77	0.75
15-24	8.83	1.77	5.37
25-44	5.34	1.16	3.21
45-64	3.18	0.84	1.97
65+	7.98	6.15	6.89
Total	4.63	1.77	3.16

Table 11 displays the distribution of fatal and non-fatal SCI cases. A Mantel-Henzsel test for homogeneity of fatal and non-fatal cases among age groups reveals that some age groups are more likely to die from SCI than others (Fisher's Exact test, $P < 0.001$). Further analysis suggests that for each increase in age range, a person is more likely to die from a SCI (OR = 1.84, 95% confidence interval = 1.38-2.46).

Table 11. Fatal and non-fatal SCI by age, 1999

Age Range	Fatal	%	Non-Fatal	%	Total	%
5-14	2	2.9	2	3.6	4	3.2
15-24	11	15.7	20	36.4	31	24.8
25-44	18	25.7	20	36.4	38	30.4
45-64	9	12.9	9	16.4	18	14.4
65+	30	42.9	4	7.3	34	27.2
Total	70	100.0	55	100.0	125	100.0
Fisher's Exact Test—P < 0.001						

It should also be noted in Table 12 that fatal and non-fatal SCI are distributed unevenly among males and females ($\chi^2 = 5.40$, $P = 0.02$). Simple univariate analysis reveals that, unlike TBI, females are more likely to die from a SCI than males (OR = 2.66, 95% confidence interval = 1.16-6.07).

Table 12. Fatal and non-fatal SCI by gender, 1999

Gender	Non-Fatal	%	Fatal	%	Total	%
Female	10	18.2	26	37.1	36	28.8
Male	45	81.8	44	62.9	89	71.2
Total	55	100.0	70	100.0	125	100.0
$\chi^2 = 5.40$ (P = 0.02)						

Causes of SCI

The major causes of SCI listed in Table 13 are similar to those of TBI. Motor vehicle traffic accidents accounted for 36.8% of all SCI, followed by falls (17.6%), and other transport accidents (13.6%). A Fisher's Exact test yields a P-value of <0.001, indicating that some causes of SCI are significantly more likely to lead to fatalities. The cause with the highest fatality rates was motor vehicle traffic accident (65.2% fatal). Overall, 56% of cases resulted in a fatality.

Table 13. Major causes of SCI, 1999

Cause	Non-Fatal	%	Fatal	%	Total	%
Motor Vehicle Traffic Accident	16	29.1	30	42.9	46	36.8
Falls	13	23.6	9	12.9	22	17.6
Other Transport Accident	13	23.6	4	5.7	17	13.6
Other	8	14.5	6	8.6	14	11.2
Homicide/Assault	4	7.3	3	4.3	7	5.6
Suicide	1	1.8	0	0.0	1	0.8
Unknown	0	0.0	18	25.7	18	14.4
Total	55	100.0	70	100.0	125	100.0
Fisher's Exact Test—P < 0.001						

Primary Payer

Primary payers are listed in Table 14. Primary payer data were available for all 35 records from the HDD. Commercial insurance was the most commonly listed primary payer for SCI cases in 1999 (51.4% of cases). Medicare and Medicaid combined accounted for 22.8% of all SCI cases.

Table 14. Primary payers for SCI cases in HDD, 1999

Primary Payer	Non-Fatal	%	Fatal	%	Total	%
Commercial	16	50.0	2	66.7	18	51.4
Other	7	21.9	0	0.0	7	20.0
Medicaid	4	12.5	0	0.0	4	11.4
Medicare	3	9.4	1	33.3	4	11.4
Workers Compensation	2	6.3	0	0.0	2	5.7
Total	32	100.0	3	100.0	35	100.0

Discharge Status

Table 15 lists the discharge status from the SCI cases in the HDD. Discharge status was present for every HDD record. "Discharged/Transferred to another type of institution for inpatient care or referred for outpatient services to another institution" was the most common status—48.57% of all 1999 SCI cases in the HDD. "Discharged Home" was listed for 37.14% of 1999 SCI cases in the HDD.

Table 15. Discharge status of SCI cases in HDD, 1999

Discharge Status	Frequency	Percent
Discharged/Transferred to another type of institution for inpatient care or referred for outpatient services to another institution	17	48.6
Discharged Home*	13	37.1
Discharged/Transferred to home under care of organized home health service organization	2	5.7
Expired	2	5.7
Other/Unknown	1	2.9
Total	35	100.0

*Although the HDD record for one particular individual lists status as "Discharged Home", the record linked to a NCHS death record. This is why there are 3 total deaths in Table 14, but only 2 listed as "Expired" in Table 15.

Length of Stay

Data on the length of hospital stay was available for 60 cases in the HDD and Trauma data. The mean, median, mode, and maximum LOS are listed in Table 15. The total number of days spent in the hospital, collectively, by SCI patients in 1999 was 792.

Table 15. Length of stay for SCI patients, 1999

Length of Stay	
# Cases	60
Mean	13.2
Median	10
Mode	10
Maximum	110
Total	792

Work-Related SCI

Only 2 SCI cases were found to be work-related for 1999. These were both identified from the HDD since primary payer was listed as workers' compensation. Neither was a fatality.

RESULTS—ABI IN KENTUCKY, 1999

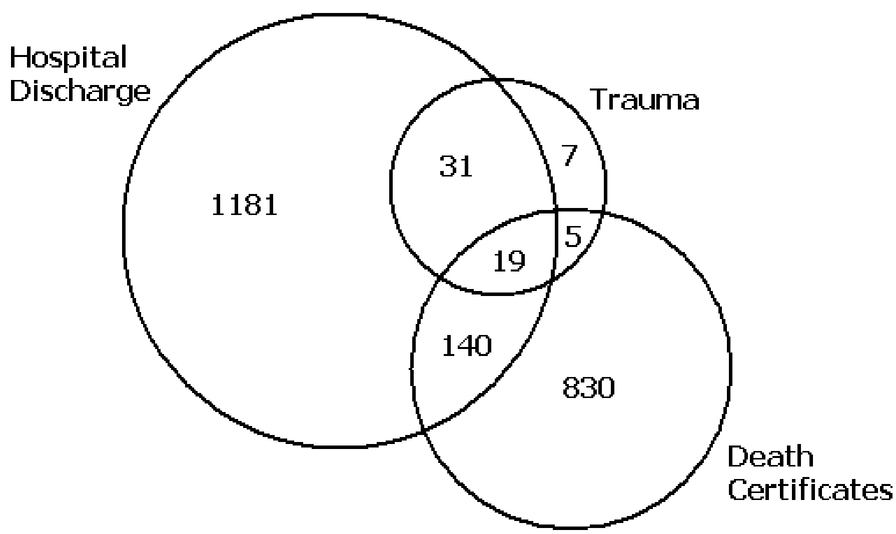
Table 16 and the Venn diagram in Figure 4 show the number of ABI cases found only in a single data set, in two data sets, or in all three.

Table 16. Data sources and distribution of ABI among them, 1999

Data Source	Non-Fatal	Fatal	Total
HDD Inpatient Only	1143	38	1181
Trauma Only	7	0	7
NCHS Death Only	0	830	830
Trauma & HDD	29	2	31
Trauma & NCHS Death	0	5	5
HDD & NCHS Death	4	136	140
Trauma & NCHS Death & HDD	0	19	19
Total	1183	1030	2213

A total of 2213 cases of ABI were identified for calendar year 1999. This is considerably more than the 1573 identified for 1998. This number of cases results in an incidence rate of 55.9 ABI per 100,000 residents in Kentucky.

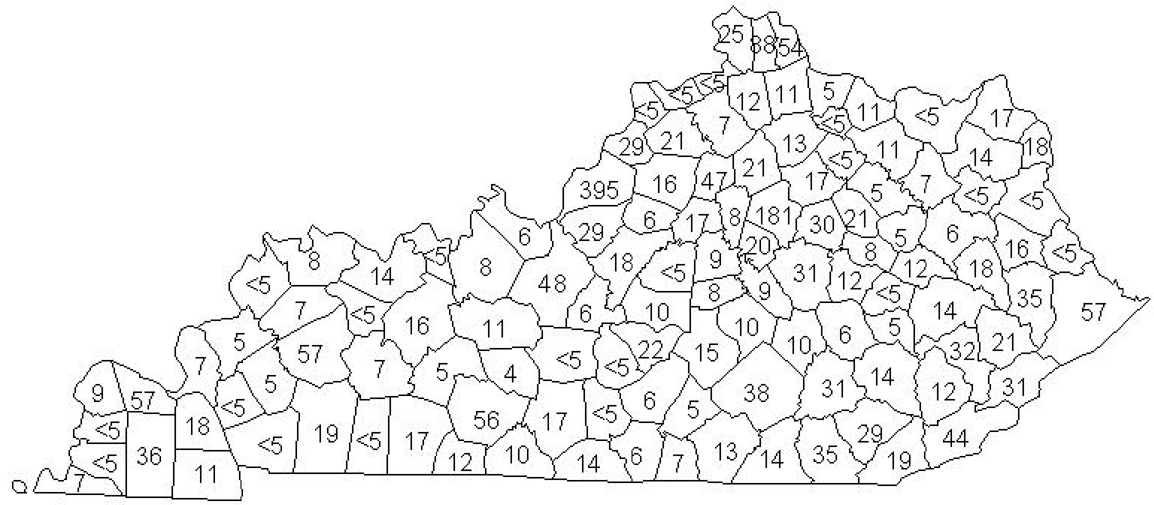
Figure 4. Data sources and ABI case distribution among them, 1999



Geographic distribution of ABI

Figure 5 displays the geographic distribution of ABI throughout Kentucky by the patients' counties of residence. Jefferson county had the most cases of ABI; there were 395 in 1999. Fayette county had the next highest number of cases, with 181.

Figure 5. Geographic distribution of ABI, 1999



A complete list of all counties and their respective ABI incidence rates is available in the Appendix (Table A-3).

<u>ABI by Age, Gender</u>

Table 17 lists the age and gender specific incidence rates for ABI. Rates for males are higher than those for females in every age group, but especially in the 25-44 age group.

Table 17. Age- and gender-specific incidence rates for ABI, 1999

Age Range	Males	Females	Total
0-4	27.8	22.2	25.1
5-14	9.5	7.7	8.6
15-24	28.5	22.3	25.5
25-44	62.1	38.2	50.0
45-64	67.6	54.7	60.9
65+	189.1	146.2	163.6
Total	61.6	50.5	55.9

Separate age-specific incidence rates for the 4 main categories of ABI (anoxia/hypoxia, allergy/anaphylaxis, infection, and toxic substances) and for cases where multiple categories applied, are shown in Table 18. Overall, and at every age, the incidence rate for toxic substances is higher than the other categories, except for those 65 and older, where the anoxia/hypoxia rate is much higher.

Table 18. Age-specific incidence rates for categories of ABI, 1999

Age Range	Anoxia/hypoxia	Allergy/ anaphylaxis	Infection	Toxic Substances	Multiple
0-4	5.0	1.9	0.8	15.1	2.3
5-14	1.5	0.4	0.7	4.3	1.7
15-24	5.0	0.2	1.0	19.1	0.2
25-44	8.5	1.4	1.3	36.6	2.1
45-64	22.0	2.4	1.3	33.1	2.1
65+	92.1	2.8	2.6	62.3	3.9
Total	20.3	1.5	1.3	30.7	2.0

Table 19 displays the gender-specific rates for the 4 categories of ABI. All categories were more common in males, except allergy/anaphylaxis, where females had a slightly higher incidence rate.

Table 19. Gender-specific incidence rates for categories of ABI, 1999

Gender	Anoxia/ hypoxia	Allergy/ anaphylaxis	Infection	Toxic Substances	Multiple
M	23.7	1.2	1.5	32.8	2.4
F	17.2	1.8	1.2	28.7	1.6
Total	20.3	1.5	1.3	30.7	2.0

Table 20 displays the distribution of fatal and non-fatal ABI cases. A Mantel-Henzsel test for homogeneity of fatal and non-fatal cases among age groups reveals that some age groups are more likely to die from ABI than others ($\chi^2 = 122.00$, $P < 0.001$). Further analysis suggests that for each increase in age range, a person is more likely to die from an ABI (OR = 1.43, 95% confidence interval = 1.33-1.53).

Table 20. Fatal and non-fatal ABI by age, 1999

Age Range	Fatal	%	Non-Fatal	%	Total	%
0-4	15	1.5	50	4.2	65	2.9
5-14	13	1.3	33	2.8	46	2.1
15-24	55	5.3	92	7.8	147	6.6
25-44	197	19.1	394	33.3	591	26.7
45-64	270	26.2	287	24.3	557	25.2
65+	480	46.6	327	27.6	807	36.5
Total	1030	100.0	1183	100.0	2213	100.0
Test for homogeneity $\chi^2 = 122.00$ ($P < 0.0001$) Test for trend $\chi^2 = 105.14$ ($P < 0.0001$)						

Table 21 shows that fatal and non-fatal ABI are, like SCI and TBI, distributed unevenly among males and females ($\chi^2 = 24.96$, $P < 0.001$). Similar to TBI, men are more likely to suffer a fatal ABI than women (OR = 1.54, 95% confidence interval = 1.30-1.82).

Table 21. Fatal and non-fatal ABI by gender, 1999

Gender	Non-Fatal	%	Fatal	%	Total	%
Male	575	48.6	610	59.2	1185	53.6
Female	608	51.4	420	40.8	1028	46.5
Total	1183	100.0	1030	100.0	2213	100.0
						χ^2 = 24.96 (P < 0.001

Causes of ABI

The major causes of ABI are listed in Table 22. Toxic substances accounted for 54.90% of all ABI—more than all other causes combined. However, analysis reveals that fatalities are distributed unevenly among causes (χ^2 = 571.27, P < 0.001). Due to this uneven distribution, it is anoxia/hypoxia that accounts for the greatest number of fatalities (61.84%) among ABI cases, even though there are far more ABI due to toxic substances.

Table 22. Major causes of ABI, 1999

Cause	Non-Fatal	%	Fatal	%	Total	%
Toxic Substances	880	74.4	335	32.5	1215	54.9
Anoxia/Hypoxia	169	14.3	637	61.8	806	36.4
Combination of causes	37	3.1	42	4.1	79	3.6
Allergy/Anaphylaxis	58	4.9	3	0.3	61	2.8
Infection	39	3.3	13	1.3	52	2.4
Total	1183	100.0	1030	100.0	2213	100.0
						χ^2 = 571.27, P < 0.001

Primary Payer

Primary payers for ABI are listed in Table 23. Primary payer data were available for all but 3 records from the HDD. The overwhelming majority was Self Pay in 1999, with 73.4% of cases. Commercial primary payers were the next largest group, and accounted for only 10.7% of ABI cases.

Table 23. Primary payers for ABI cases in HDD, 1999

Primary Payer	Non-Fatal	%	Fatal	%	Total	%
Self Pay	717	60.6	908	88.2	1625	73.4
Commercial	190	16.1	46	4.5	236	10.7
Medicare	82	6.9	27	2.6	109	4.9
Medicaid	84	7.1	19	1.8	103	4.7
Workers Compensation	59	5.0	21	2.0	80	3.6
Other	43	3.6	4	0.4	47	2.1
Other Federal programs	4	0.3	4	0.4	8	0.4
Unknown	3	0.3	0	0.0	3	0.1
CHAMPUS	1	0.1	1	0.1	2	0.1
Total	1183	100.0	1030	100.0	2213	100.0

Discharge Status

Table 24 lists the discharge status for the ABI cases in the HDD. Discharge status was present for 1339 of 1371 HDD records (97.7%). "Discharged Home" was the most common status, at 52.8% of all 1999 ABI cases in the HDD. "Expired" was next most common discharge status, representing only 14.4% of cases.

Table 24. Discharge status of ABI cases in HDD, 1999

Discharge Status	Frequency	Percent
Discharged Home	707	52.8
Expired	193	14.4
Discharged/Transferred to another type of institution for inpatient care or referred for outpatient services to another institution	150	11.2
Discharged/Transferred to skilled nursing facility	107	8.0
Discharged/Transferred to home under care of organized home health service organization	70	5.2
Discharged/Transferred to another short term general hospital for inpatient care	44	3.3
Left against medical advice or discontinued care	34	2.5
Other	21	1.6
Discharged/Transferred to intermediate care facility	13	1.0
Total	1339	100.0

Length of Stay (LOS)

Data on the length of hospital stay was available for 1250 cases in the HDD and Trauma data. The mean, median, mode, and maximum LOS are listed in Table 25. The total number of days spent in the hospital, collectively, by ABI patients in 1999 was 20,083.

Table 25. Length of stay for ABI patients, 1999

Length of Stay	
# Cases	1250
Mean	16.1
Median	5
Mode	1
Maximum	225
Total	20,083

Work-Related ABI

There were 80 cases of ABI that listed Workers' Compensation as the primary payer, indicating that there are more work-related ABI than TBI and SCI combined. In addition, 21 of these 80 cases (26.3%) were fatalities, whereas there were no fatalities among work-related TBI and SCI cases.

DISCUSSION

Incidence Rates

The incidence rate reported for TBI in Kentucky for 1999 is 76.7 per 100,000. This is much lower than the U.S. average—95 per 100,000. The incidence rates for 1997 and 1998 were 83 per 100,000 and 62.5 per 100,000, respectively. This discrepancy has long been suspected to be due to low UB-92 reporting, resulting in fewer HDD records. With only 3 years of data, it is difficult to correlate the number of TBI in the HDD with the total number of HDD records. However, there does seem to be an association, even if it cannot yet be shown to be significant because there are so few years of data.

Table 26. HDD and TBI trends

Year	HDD Records	TBI in HDD	% of HDD identified as TBI
1997	40,679	1745	4.3
1998	36,805	1329	3.6
1999	39,278	1824	4.6
			Correlation coefficient, $r = .87$, $P < 0.40$

Table 26 lists the total number of HDD records and TBI identified in the HDD for the last 3 years that have been analyzed. The correlation coefficient is 0.87, indicating that the more HDD records there are, the more TBI there are to be found. However, the P-value for the correlation is merely <0.40, which is hardly significant. At least 2-3 more years of data would be necessary to reach significance, if the trend holds. If the trend does hold, and this correlation is not spurious, a larger HDD should result in more TBI being identified. Compdata, Kentucky's new vendor for UB-92 data processing and collection, has significantly improved data quality and quantity. The HDD for 2000, Compdata's first year as vendor, contains about 60,000 records! In the last 3 years, the average percentage of HDD records identified as TBI is 4.19%. If this holds for the year 2000 data, almost 2500 TBI could be identified in the HDD alone!

Unfortunately, similar analyses cannot yet be performed for SCI and ABI data. SCI surveillance began only in 1998, and the ABI definition has changed over the past 3 years, rendering comparison impossible.

Age and Gender as Risk Factors

There is a tendency for TBI, SCI, and ABI to strike the elderly more frequently than the young. The incidence rates for TBI, SCI, and ABI were always highest among the elderly. Table 27 shows the two highest age-specific incidence rates for each type of injury (TBI, SCI, ABI). Note that for ABI, the 65+ incidence rate is more than twice that of the next highest group.

Table 27. Comparison of incidence rates for TBI, SCI, and ABI

Type of Injury	Highest IR (Age Group)	Next Highest IR (Age Group)	IR ratio
TBI	145.4 (65+)	106.6 (15-24)	1.4
SCI	6.89 (65+)	5.37 (15-24)	1.3
ABI	163.6 (65+)	60.9 (45-64)	2.7

Besides being more common in the elderly, TBI, SCI, and ABI are also more *fatal* in the elderly. The odds ratios for each increase in age range are 1.27, 1.84, and 1.43 for TBI, SCI, and ABI, respectively. This indicates that the older people become, the more likely they are to die from one of these injuries.

In addition to the elderly, men tend to be at greater risk than women for TBI, SCI, and ABI. TBI is more than twice as common in men than women (IR ratio=2.3), as is SCI (IR ratio=2.6). Only ABI has an incidence rate that is similar for men and women (IR ratio=1.22). Fatalities are also distributed unevenly between genders, with male TBI and ABI sufferers more likely to die than their female counterparts (OR=1.72 and OR=1.54, respectively). Interestingly, women who sustain SCI are much more likely to die than men (OR=2.66).

Future Directions

The addition of emergency department (ED) data would help identify more cases of TBI, SCI, and ABI. KIPRC and the Kentucky Department of Public Health (KDPH) have explored possibilities for obtaining these data. It is possible for Compdata, who already has the raw data, to process ED data for a fee of $0.17 per record. To process every record would be impossible due to cost, but processing a subset (only injury records, for example) may be affordable.

A more comprehensive study of the effects of age and gender on TBI, SCI, and ABI incidence and severity is greatly needed. It is the intention of the project manager to perform such a study, believing prevention and services professionals alike would benefit from it. Other topics that may be ripe for study include causation as it relates to severity or fatalities, trends in primary payers and hospital charges or fatalities, and capture-recapture analysis to reveal how many cases of TBI, SCI, and ABI the surveillance system may be missing.

In addition to more in-depth analyses, it is important that surveillance continue in a similar fashion. Only by continuing surveillance through data linkage with the same data sets can trends be identified and processes perfected. The data abstraction, however, has become less important to the project as hospital discharge data have improved with regard to general completeness and quality. Indeed, if any abstraction is to take place in the future, it should only be performed for a relatively small random sample, and targeted towards specific studies or research questions.

APPENDIX

Table A-1. TBI incidence rates by county, 1999

COUNTY	IR	COUNTY	IR	COUNTY	IR	COUNTY	IR	COUNTY	IR
Lewis	193.0	Menifee	119.4	Franklin	88.0	Trimble	63.1	Webster	37.1
Knott	184.0	Letcher	118.9	Floyd	87.8	Todd	62.0	Martin	33.6
Nicholas	182.4	Marion	116.8	Hopkins	86.7	Henry	59.9	Kenton	33.3
Clinton	169.1	Cumberland	116.3	Edmonson	86.2	Caldwell	59.9	Ohio	31.6
Wolfe	159.9	Mercer	115.3	Magoffin	85.5	Rowan	58.6	Bullitt	27.9
Perry	159.1	Pike	113.2	McCracken	83.8	Hickman	58.3	Greenup	24.5
Jackson	153.4	Carroll	112.5	Metcalfe	83.4	Meade	58.2	Boone	22.8
Monroe	152.4	Owsley	111.6	Montgomery	83.2	Spencer	57.5	Daviess	19.7
Rockcastle	150.2	Pulaski	110.3	Bracken	82.6	Warren	57.0	Union	18.2
Bath	149.0	Johnson	108.3	Fulton	80.5	Muhlenberg	56.3	Boyd	14.3
Harlan	148.8	Breathitt	107.8	Breckinridge	79.0	Carlisle	55.7	Henderson	13.5
Lincoln	142.0	Taylor	104.6	Adair	79.0	Gallatin	53.8	Hancock	0.0
Bourbon	139.4	Trigg	103.2	Hart	77.1	Larue	53.2		
Bell	137.8	Boyle	102.3	Madison	72.4	Shelby	52.4		
McCreary	137.3	Clark	101.7	Pendleton	71.6	Barren	50.9		
Harrison	135.9	Morgan	95.2	Woodford	70.3	Lawrence	50.6		
Estill	135.4	Laurel	94.2	Anderson	69.1	Christian	50.0		
Whitley	132.9	Crittenden	94.2	Fayette	68.9	Lyon	49.6		
Simpson	132.6	Ballard	93.9	Logan	68.5	Russell	49.4		
Garrard	132.6	Wayne	93.8	Nelson	67.6	Calloway	48.1		
Robertson	132.5	Marshall	92.6	Jefferson	67.3	Elliott	45.9		
Knox	131.3	Butler	91.5	Owen	67.2	Hardin	45.9		
Powell	128.2	Washington	90.5	Grayson	67.1	Carter	44.3		
Casey	127.4	Scott	89.9	Graves	66.2	Oldham	43.6		
Clay	127.3	Mason	89.2	Fleming	66.2	McLean	40.4		
Leslie	125.4	Allen	89.0	Green	66.1	Grant	38.5		
Lee	125.1	Jessamine	88.5	Livingston	63.3	Campbell	37.8		

Table A-2. SCI incidence rates by county, 1999

Hancock	33.42	Knox	6.25	Kenton	1.36	Jessamine	0.00	Spencer	0.00
Gallatin	26.89	Russell	6.18	Allen	0.00	Johnson	0.00	Todd	0.00
Casey	20.12	Adair	6.07	Ballard	0.00	Larue	0.00	Trigg	0.00
Green	18.88	Laurel	5.77	Bell	0.00	Lee	0.00	Union	0.00
Clay	17.56	Campbell	5.73	Boone	0.00	Letcher	0.00	Warren	0.00
Caldwell	14.96	Anderson	5.32	Boyd	0.00	Logan	0.00	Webster	0.00
Cumberland	14.54	Pulaski	5.25	Bracken	0.00	McCracken	0.00	Wolfe	0.00
Trimble	12.62	Bourbon	5.16	Breathitt	0.00	McCreary	0.00	Woodford	0.00
Lyon	12.41	Grant	4.81	Butler	0.00	McLean	0.00		
Breckinridge	11.28	Mercer	4.81	Calloway	0.00	Marion	0.00		
Knott	11.15	Floyd	4.62	Carlisle	0.00	Martin	0.00		
Graves	11.03	Montgomery	4.62	Carroll	0.00	Mason	0.00		
Boyle	10.97	Lincoln	4.44	Carter	0.00	Menifee	0.00		
Livingston	10.55	Taylor	4.36	Clinton	0.00	Metcalfe	0.00		
Wayne	10.42	Marshall	3.31	Crittenden	0.00	Morgan	0.00		
Bath	9.31	Shelby	3.27	Daviess	0.00	Muhlenberg	0.00		
Washington	9.05	Perry	3.25	Elliott	0.00	Nelson	0.00		
Monroe	8.96	Jefferson	3.12	Estill	0.00	Nicholas	0.00		
Hopkins	8.67	Scott	3.10	Fleming	0.00	Ohio	0.00		
Edmonson	8.62	Clark	3.08	Fulton	0.00	Oldham	0.00		
Barren	8.03	Madison	2.95	Grayson	0.00	Owen	0.00		
Jackson	7.67	Pike	2.80	Greenup	0.00	Owsley	0.00		
Lewis	7.42	Christian	2.78	Hardin	0.00	Pendleton	0.00		
Leslie	7.38	Whitley	2.77	Harlan	0.00	Powell	0.00		
Magoffin	7.12	Fayette	2.46	Harrison	0.00	Robertson	0.00		
Garrard	6.98	Henderson	2.25	Hart	0.00	Rockcastle	0.00		
Meade	6.85	Franklin	2.15	Henry	0.00	Rowan	0.00		
Lawrence	6.33	Bullitt	1.64	Hickman	0.00	Simpson	0.00		

Table A-3. ABI incidence rates by county, 1999

COUNTY	IR	COUNTY	IR	COUNTY	IR	COUNTY	IR	COUNTY	IR
Wolfe	159.9	Floyd	80.9	Laurel	59.6	Lincoln	44.4	McLean	20.2
Henry	139.8	Fleming	80.9	Marshall	59.5	Robertson	44.2	Union	18.2
Harlan	128.4	Pike	79.7	Allen	59.3	Morgan	43.9	Washington	18.1
Magoffin	128.2	Pendleton	78.8	Bracken	59.0	Mercer	43.3	Henderson	18.0
Monroe	125.5	Estill	77.4	Jefferson	58.7	Metcalfe	41.7	Hart	17.8
Hopkins	123.5	Fayette	74.2	Marion	58.4	Butler	41.6	Todd	17.7
Letcher	118.9	Clinton	74.0	Grant	57.7	Carroll	40.9	Daviess	15.4
Knott	117.1	Livingston	73.8	Spencer	57.5	Gallatin	40.3	Hancock	0.0
Ballard	105.7	Harrison	73.6	Nicholas	56.1	Hickman	38.9		
Perry	103.9	Simpson	72.3	Carlisle	55.7	Caldwell	37.4		
Franklin	100.9	Ohio	72.3	Jessamine	53.6	Boyd	36.9		
Casey	100.6	Wayne	67.7	Hardin	52.4	Adair	36.4		
Graves	99.3	Owen	67.2	Shelby	52.4	Woodford	35.1		
Montgomery	97.1	Johnson	66.7	Crittenden	52.3	Edmonson	34.5		
Whitley	96.9	Pulaski	66.5	Webster	52.0	Martin	33.6		
Taylor	95.9	Bell	65.5	Carter	51.6	Calloway	33.0		
Fulton	93.9	Mason	65.4	Trimble	50.5	Trigg	31.8		
Owsley	93.0	Scott	65.1	Lee	50.0	Rowan	31.6		
Clark	92.4	Logan	64.7	Nelson	48.7	Russell	30.9		
Knox	90.7	Warren	63.9	Bullitt	47.6	Boone	30.0		
Anderson	90.4	Oldham	63.3	Bath	46.6	Boyle	29.2		
Breathitt	88.8	Garrard	62.8	Greenup	46.3	Green	28.3		
Leslie	88.5	Rockcastle	62.6	Grayson	46.2	Christian	26.4		
McCracken	88.5	Campbell	61.9	Jackson	46.0	Lawrence	25.3		
Bourbon	87.8	Clay	61.5	Madison	45.8	Lyon	24.8		
Cumberland	87.3	Elliott	61.2	Larue	45.6	Lewis	22.3		
Menifee	85.3	Powell	60.3	Barren	45.5	Muhlenberg	21.9		
McCreary	83.6	Kenton	59.8	Breckinridge	45.1	Meade	20.6		