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Review of spinal cord injury statistics related to diving and diving board use

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Background

S. R. Smith LLC retained the services of American Institutes for Research (AIR) to review existing research on spinal cord injury (SCI) risks associated with diving and diving boards. The last major research study to present such data was published in 1993 (RAND Corporation's report, titled *Swimming Pool Risks: How Do They Compare To Other Accidental Risks*), and S.R. Smith sought updated risk statistics.¹ The RAND report, supported by the National Swimming Pool Foundation (NSPF), provides perspective on the risk of injury or death to society from various activities and accidental events. Specifically, it focuses on risks from activities associated with swimming pools.

AIR's goal was to identify relevant, current statistics and determine whether there are indications of trends (increases or decreases in the risk of SCI since around 1993) that can be extrapolated from the data.

The RAND report presented the risk data shown below in Table 1 for selected accidents and events derived from statistics averaged over 20 years between 1972 and 1992. Based on this information, the study's author concludes that it is 10 times more likely someone would die from a lightning strike than become quadriplegic or paraplegic because of diving in pool water deeper than six feet. Furthermore, the author states the risk of a pool-related quadriplegic or paraplegic injury is similar to the risk of death by lightning.

Table 1. Rates for occurrence of selected accidents and events².

| Accident or event | Rate per 100,000* |
|--|-------------------|
| All temporary disabling injuries | 3,600 |
| All permanent disabling injuries | 130 |
| Death by car accident | 18 |
| Suicide | 12 |
| Drowning – all causes | 1.9 |
| Quadriplegic/Paraplegic – all causes | 1.5 |
| Poison death by gas | 0.4 |
| Quadriplegic/Paraplegic – all aquatic | 0.16 |
| Death by tornado | 0.06 |
| Death by lightning | 0.05 |
| Quadriplegic/Paraplegic – all pools | 0.04 |
| Quadriplegic/Paraplegic – pool > 6' deep | 0.004 |
| Death by meteorite | <0.00001 |

*Based on US population (~267 million).

As described earlier, AIR is an independent, objective research organization. AIR is not an advocacy group, and as such, we approached this project with an unbiased eye toward the risk statistics. We did not seek to find data to “prove” the increase or decrease of spinal cord injuries related to diving, but rather to analyze and report objectively on the most current and relevant data sources.

This report summarizes the findings from studies we identified related to SCI risks associated with diving and diving boards.

Risk statistics

Analysis of the RAND document

The RAND report presents spinal cord injury (SCI) risks associated with diving into pools, but it does not specify what the specific risk is associated with diving board usage *per se*. In other words, the data do not distinguish between cases in which a diving board was used and cases where someone dived from the side of the pool or some other object. Since these data include all SCI's related to diving into pools, and many people dive into pools without using diving boards, the risk of becoming paralyzed when using diving boards is likely even lower than the RAND statistics would imply.

Therefore, upon searching for updated statistics, AIR sought to find data that specifically indicate the risks associated with diving board usage in addition to risks associated with swimming pools and diving. We identified the following statistics.

Current data on spinal cord injuries

According to the National Spinal Cord Injury Statistical Center (NSCISC), there are roughly 11,000 reported incidences of SCI (from all causes, including diving boards) per year in the United States.³ This represents an injury rate of 3.9 per 100,000 based on the 2000 U.S. population.

Nobunaga, Go and Karunas⁴ have analyzed trends of SCI using the NSCISC's database since its inception in 1973. As shown in Table 2, annual averaged data suggest that reported rates of SCI have been approximately constant during the 16-year period 1983 to 1998.

Table 2. Reported SCI in NSCISC database from 1973-1998.

| Period | Reported SCI | Annual average |
|-----------|--------------|----------------|
| 1973-1977 | 2,710 | 542 |
| 1978-1982 | 4,555 | 911 |
| 1983-1988 | 6,453 | 1075 |
| 1989-1993 | 5,883 | 1177 |
| 1994-1998 | 5,453 | 1091 |

The question is: what proportion of these statistics result from diving board use, and how has that number changed (if at all) over the past decade?

One source of data is the Consumer Product Safety Commission's National Electronic Injury Surveillance System (CPSC's NEEIS). The CPSC's NEEIS compiles data from hospital emergency department records that mention a consumer product or recreational activity in association with an injury. Some

reported injuries are associated with more than one product. The CPSC notes that conclusions about the cause of accident should not be drawn from this data.

The data presented in Table 3 below are statistically estimated injuries for 2001 based on NEISS's sampling of participating hospitals. Table 3 summarizes data regarding aquatic products and activity injuries involving diving and diving boards.

Table 3. Sources of aquatic product and activity injuries requiring hospitalization, United States, 2001⁵.

| Aquatic product and activity | Estimated injuries |
|--|--------------------|
| Swimming (activity, apparel, or equip) | 76,408 |
| Swimming pools, not specified | 60,279 |
| Built-in swimming pools | 19,233 |
| Diving or diving boards | 11,196 |
| Whirlpools, hot tubs or home spas | 7,600 |
| Water slides (public, backyard/home, or other) | 6,226 |
| Water tubing (activity, apparel, or equip) | 4,340 |
| Swimming pool equipment | 4,040 |
| Swimming pool chemicals | 3,315 |
| Above-ground swimming pools | 1,882 |

However, these statistics aggregate diving and diving board data together, making it impossible to tease out the actual risk of using diving boards.

According to NSCISC data shown in Table 4 below between 1973 to 1998⁶, diving mishaps have accounted for 7.3% of reported SCI and ranked fourth in terms of declining frequency below auto accidents, falls and gunshot wounds. Diving is one of 37 etiologies for SCI that are tracked in the NSCISC database. The database does not distinguish between injuries occurring in swimming pools and natural aquatic environments such as lakes and oceans.

Table 4. Leading causes of SCI, 1973-1998.

| Cause | Injuries | % |
|------------------------|----------|------|
| Auto accidents | 6,741 | 34.3 |
| Falls | 3,378 | 19.0 |
| Gunshot | 3,348 | 17.0 |
| Diving | 1,443 | 7.3 |
| Motorcycle | 1,109 | 5.6 |
| Hit by falling objects | 648 | 3.3 |
| Medical/surgical | 411 | 2.1 |
| Pedestrian | 348 | 1.8 |
| All others | 2,222 | 11.3 |

As shown in Table 5 below, Nobunaga, Go and Karunas⁷ analyzed trends in SCI etiologies over a 26-year period using the NSCISC database. The data indicate the percent of reported SCI caused by diving has declined from a peak of 9.1% during the 5-year period 1978-1982 to low of 5.0% during the most recent 5-year period 1994-1998.

Table 5. *Leading causes of SCI by year of injury*⁸.

| Cause | 1973-1977 | 1978-1982 | 1983-1988 | 1989-1993 | 1994-1998 |
|------------------------|-----------|-----------|-----------|-----------|-----------|
| Auto accidents | 36.9 | 38.1 | 35.4 | 32.5 | 33.7 |
| Falls | 16.9 | 15.8 | 19.2 | 19.3 | 21.3 |
| Gunshot | 12.9 | 12.7 | 14.6 | 22.0 | 20.1 |
| Diving | 9.0 | 9.1 | 8.4 | 5.8 | 5.0 |
| Motorcycle | 6.6 | 7.2 | 6.0 | 4.7 | 4.2 |
| Hit by falling objects | 5.8 | 4.1 | 3.3 | 3.0 | 2.8 |
| Medical/surgical | 1.2 | 1.5 | 1.6 | 1.7 | 2.4 |
| Pedestrian | 1.4 | 1.2 | 1.5 | 1.6 | 1.6 |
| All others | 10.0 | 11.5 | 11.3 | 11.0 | 11.1 |

DeVivo and Sekar⁹ analyzed SCI's occurring in swimming pools from a follow-up survey with 1106 individuals in the NSCISC database who sustained injuries between 1973 and 1994.

According to DeVivo and Sekar's research, at least 30.8% (341) of SCI's occurred diving in a swimming pool as shown in Table 6 below.

Table 6. *Aquatic location of SCI from diving*¹⁰.

| Injury location | Injuries | % |
|-----------------|----------|------|
| Total | 1,106 | |
| Natural body | 631 | 57.1 |
| Swimming pool | 341 | 30.8 |
| Unknown | 134 | 12.1 |

Of the 341 individuals sustaining a SCI due to diving in a swimming pool, 57.5% (196) completed the follow-up survey regarding the circumstances of their injury¹¹. More injuries occurred in below-ground swimming pools (64%) than in above-ground swimming pools (36%).

From the follow-up survey data shown in Table 7, DeVivo and Sekar reported 76.8% of SCI's from diving in a swimming pool did not involve any pool equipment while 10.2% involved a low or high diving board.

Table 7. Devices used during SCI from diving¹².

| Device | Injuries | % |
|--------------------|----------|------|
| None | 142 | 76.8 |
| Low diving board | 16 | 8.6 |
| Competition blocks | 9 | 4.9 |
| Ladder or steps | 8 | 4.3 |
| Other | 7 | 3.8 |
| High diving board | 3 | 1.6 |
| Unknown | 11 | 5.6 |

From the follow-up survey data shown in Table 8, DeVivo and Sekar reported that 4.8% of the SCI from diving into swimming pools occurred in water greater than 8 feet deep.

Table 8. Water depth during SCI from diving in swimming pools¹³.

| Water depth | Injuries | % |
|---------------------------|----------|------|
| Shallow (0 - 4 ft) | 107 | 57.2 |
| Intermediate (4.1 - 8 ft) | 71 | 38.0 |
| Deep (>8 ft) | 9 | 4.8 |
| Unknown | 9 | - |

From the follow-up survey data shown in Table 9, DeVivo and Sekar reported 69.7% of SCI resulted from an ordinary dive and 16.8% resulted from an unusual dive.

Table 9. SCI based on diving intention¹⁴.

| Intentionality | Injuries | % |
|-----------------------------|----------|------|
| Ordinary dive | 129 | 69.7 |
| Unusual dive | 31 | 16.8 |
| Other | 13 | 7.0 |
| Pushed (unintentional/play) | 11 | 6.0 |
| Pushed (intent to harm) | 1 | 0.5 |

Conclusions

What we learned

In conducting our research, we learned:

Diving board-related injuries are not generally specified

The statistics kept by safety agencies like the CPSC are not specific enough to draw conclusions comparing the relative risks of diving board usage. Compared to other causes of death and injury, diving boards represent such a small factor that injuries attributed to diving boards are uncommon.

For documenting the cause of injuries, *diving* is an ambiguous category that typically refers to any non-swimming aquatic activity. While this category includes diving board use, it may also include use of other swimming equipment and waterside jumping. Consequently, the presented injury statistics lack specificity but provide an upper boundary for comparisons to other causes or activities.

Extant SCI statistics provide limited insight into diving-board-related risks and injuries. As discussed above, the statistics from the NSCISC attribute some SCI to diving but are not specific to diving board usage. We assume that specific diving board-related SCI must be less than reported SCI caused by diving.

Missing data for participants in swimming or diving activities

Lacking accurate knowledge of how many and how often people participate in swimming pool activities prevents an accurate assessment of diving board-related injury rates. For example, infants, the elderly, people lacking swimming skills, or people without easy access to pools are less likely to use a swimming pool and become a diving board-related injury victim. Accordingly, we view diving board-related injuries as a risk to a subset of the U.S. population. Consistent with NSCISC's viewpoint¹⁵, it is not appropriate to use total population data to derive injury rates for comparing to other causes. Populations of other groups such as pool and diving board owners, pool users, swimmers, teenagers, etc. would provide additional insights.

A risk analysis

Our research yielded a set of data regarding the nature of injuries involving diving and diving boards. We determined there to be a shortage of substantial data defining injury rates related to use of diving boards specifically. For the purposes of obtaining rough estimates of diving board-related injury risks, we present an estimate of diving board-related SCI rates with caveats.

It important to note that these injury rates:

- Only represent one kind of diving board-related injury – spinal cord injury,
- Are based on how the NSCISC reports SCI incidents from diving in swimming pools and natural aquatic environments,

- Do not consider the frequency or duration of swimming by participants in aquatic activities, and
- Do not consider how risk varies according to demographic and environmental factors, such as age, gender, pool type, diving board type, or setting (i.e., residential, community center, etc.).

We used the following assumptions to derive these injury rate estimates:

- Based on estimates from the National Sporting Goods Association (NSGA), we assumed that approximately 60.7 million out of 281.4 million people (21.6%) in the US regularly participate in swimming activities and are at risk for diving and diving board-related SCI's.
- Assuming the most recent data in the NSCISC database is representative of SCI injuries to the general population, we estimate that approximately 550 new SCI's (1998 = 5% of 11,000) occur each year because of diving into swimming pools and natural aquatic environments.
- DeVivo and Sekar showed that at least 30.8% of SCI from diving had occurred in swimming pools. This leads us to estimate that around 169 SCI's occur annually from diving in swimming pools.
- Based on DeVivo and Sekar's report that 64% of SCI from diving had occurred in below-ground swimming pools, our best estimate is that 108 SCI's occur annually from diving into below-ground swimming pools.
- The researchers also reported that 10.2% of SCI from diving into swimming pools had occurred with a diving board so our best estimate is that 17 SCI's occur annually.
- Lastly, the researchers reported that 4.8% of SCI from diving into swimming pools had occurred in water greater than 8 feet so we estimate that 8 SCI's occur annually.

Table 10. Risk analysis results.

| Statistic | Injuries or drownings per year (2001 data) | Rate per 100,000 population ^a | Rate per 100,000 swimmers ^b |
|---|--|--|--|
| Hospitalized swimming injuries | 164,255 | 58 | 271 |
| Hospitalized swimming pool injuries | 80,110 | 28 | 132 |
| Hospitalized diving and diving board injuries | 11,196 | 4.0 | 18 |
| SCI - all | 11,000 | 3.9 | - |
| SCI - diving | 550 ^c | 0.20 | 0.91 |
| SCI - swimming pool diving | 169 ^c | 0.060 | 0.28 |
| SCI - below-ground swimming pool diving | 108 ^c | 0.038 | 0.18 |
| SCI - swimming pool diving boards | 17 ^c | 0.0060 | 0.028 |
| SCI - diving in swimming pool >8 feet | 8 ^c | 0.0028 | 0.013 |

^a 281,422,000 US population (2000); ^b 60,700,000 estimated swimming participants; ^c estimated

As shown in Table 10 above, we estimate the rate of SCI due to diving into swimming pools from diving boards to be on the order of 0.028 per 100,000 swimmers and 0.006 per 100,000 U.S. population for the year 2001. While several factors inevitably introduce uncertainty into our SCI risk estimates, we believe the order of magnitude is useful for assessing the prevalence of SCI's.

Comparable data related to the risk of SCI due to diving board usage are unavailable for the period covered by the RAND report, and so a comparison of our estimates to earlier estimates is not possible. Although we cannot draw conclusions about whether the risks have increased or decreased over time, we estimate that the risk of SCI from diving into a pool *using a diving board* is a highly unlikely event for individuals in the general population and swimmers, specifically.

About the American Institutes for Research

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Resources

In the course of collecting data for this report, we obtained information primarily from publications, public organizations' reports, and peer-reviewed journal articles. The sections below contain additional information about these resources.

Annual publications

Our report draws on information published annually in *Injury Facts*® by the National Safety Council and *The New York Times Almanac* by Penguin Putnam, Inc. *Injury Facts*, formerly *Accident Facts*, compiles U.S. statistics on unintentional injuries, costs, trends and other characteristics. *The New York Times Almanac* is a general interest almanac. Its editor, John W. Wright, formally edited the *Universal Almanac* referenced in the RAND report.

Organizations

Organizations maintaining public injury databases relevant to diving and swimming pools are described in the paragraphs below.

Consumer Product Safety Commission (CPSC)^a

The CPSC is an independent federal regulatory agency that works to save lives and to keep families safe by reducing the risk of injuries and deaths associated with consumer products.

This organization maintains the National Electronic Injury Surveillance System (NEISS) for collecting data from a sample of hospitals that are statistically representative of hospital emergency rooms nationwide. From the data collected, estimates are made of the number of injuries associated with consumer products and treated in hospital emergency departments. Data are collected on a broad range of injury-related issues, covering hundreds of product categories, and provides national estimates of the number and severity of product-related injuries.

National Safety Council (NSC)^b

The NSC is a non-governmental, not-for-profit, public service organization devoted to education and influencing society to adopt safety, health, and environmental policies, practices, and procedures that prevent and mitigate human suffering and economic losses arising from preventable causes.

National Center for Dissemination of Disability Research (NCDDR)^c

The NCDDR is a branch of the Office of Special Education and Rehabilitative Services at the U.S. Department of Education that provides assistance establishing innovative projects for the delivery, demonstration, and evaluation

^a www.cpsc.org

^b www.nsc.org

^c www.ncddr.org

of comprehensive medical, vocational, and other rehabilitation services to meet the needs of individuals with spinal cord injury.

This organization sponsors the Model Spinal Cord Injury System program in conjunction with the National Spinal Cord Injury Statistical Center (NSCISC) at the University of Alabama at Birmingham's Department of Rehabilitation Medicine. The NSCISC supervises and directs the collection, management and analysis of the world's largest spinal cord injury database.

Other publication

M. Alexander Gabrielsen's recently published book *Diving Injuries, Research Findings and Recommendations for Reducing Catastrophic Injuries* (2001, CDC Press LLC, Boca Raton, FL) represents a fairly comprehensive synopsis of accidents and injury research involving diving, diving boards and swimming pools. As such, we have avoided duplicating data from the book.

Endnotes

¹ Solomon KA 1993. *Swimming Pool Risks: How Do They Compare To Other Accidental Risks*, National Swimming Pool Foundation, San Antonio, TX.

² Ibid.

³ NSCISC 2001. *Spinal Cord Injury facts and figures at a glance*, University of Alabama at Birmingham.

⁴ Nobunaga MD, Bette K, Go BK, Karunas RB 1999. *Recent demographic and injury trends in people served by the Model Spinal Cord Injury Care Systems*, Arch Phys Rehabil 80:1372-1382.

⁵ Consumer Product Safety Commission 2002. *Product Summary Report, All Products, Injury estimates for calendar year 2001*, NEISS, National Injury Information Clearing house, US Consumer Product Safety Commission, Washington, DC.

⁶ Annual Report 1999. National Spinal Cord Injury Statistical Center, University of Alabama at Birmingham.

⁷ Nobunaga MD, Bette K, Go BK, Karunas RB 1999. *Recent demographic and injury trends in people served by the Model Spinal Cord Injury Care Systems*, Arch Phys Rehabil 80:1372-1382.

⁸ Adapted from Nobunaga MD, Bette K, Go BK, Karunas RB 1999. *Recent demographic and injury trends in people served by the Model Spinal Cord Injury Care Systems*, Arch Phys Rehabil 80:1372-1382.

⁹ DeVivo MJ, Sekar P 1997. *Prevention of spinal cord injuries that occur in swimming pools*, Spinal Cord 35:509-515.

¹⁰ Ibid

¹¹ Ibid.

¹² Ibid.

¹³ Ibid.

¹⁴ Ibid.

¹⁵ National Safety Council 2002. *Injury Facts 2002 Edition (formerly Accident Facts)*, Itasca, IL.