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Article

Water tubing injury patterns among different demographics: A NEISS study

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SUMMARY

Water tubing/rafting is a popular recreational activity in the United States, especially during warmer months. This activity results in various types of incidents such as falling off the inflatable, colliding with another person, or colliding with obstacles. Despite the widespread participation in water tubing and the related high injury risks, there is insufficient research on water tubing injury patterns. To address this gap in knowledge, we sought to analyze water tubing injury patterns across different sex and age groups to determine whether additional safety measures should be implemented. We hypothesized that there are differences in injury patterns - specifically injured anatomical regions and diagnoses - between males and females, and between age groups of people in the U.S. who present to the emergency department following water tubing injuries. Differences in injury patterns between demographics would suggest that targeted safety measures should be implemented based on the participant's demographic characteristics. We analyzed National Electronic Injury Surveillance System (NEISS) data for water tubing related U.S emergency department visits from 2014-2023. There were no differences in injury patterns between male and female participants. Individuals aged 20+ had more trunk and lower extremity injuries than those aged 0-19. These findings reveal important information about water tubing injuries and suggest that a participant's demographic does not have a substantial influence on injury characteristics.

INTRODUCTION

Water tubing is any activity involving an inner tube and water. There was an average of 3,591,000 rafting participants each year from 2014-2023 in the United States (1). The high-speed nature of the activity makes falling off the tube a significant, frequent danger. Of all water tubing injuries, 49% of them are caused by impact with the water, while 16% involved collisions with another participant (2). Despite consistently high levels of participation and injury risks associated with the activity, there have not been recent studies analyzing the details of water tubing injuries. The most recent prior study that focused on water tubing injury trends was from 2013, indicating the need for reliable, up-to-date water tubing injury information (3). Additionally, the prior study did not compare injury patterns between male and female participants (3). There are clear gaps in this research area both in terms of recency and comprehensiveness.

We focused specifically on injury patterns among people of different demographic characteristics. We hypothesized that there would be statistically significant differences in injured anatomical regions and diagnoses among different sex and age groups for U.S. emergency department visits following water tubing injuries. There is substantial evidence that certain sex and age groups are more susceptible to certain injury types in sports and recreational activities, so we sought to examine whether this pattern applies to water tubing (4,5). Understanding differences in tubing injuries among different demographic groups could support the creation of targeted safety measures specific to those injuries. Overall, the analysis of water tubing injury patterns would help the activity become safer for its millions of U.S. participants. We did not find differences in injury patterns between male and female participants. However, participants who were 20 years or older had significantly more trunk and lower extremity injuries compared to participants who were 19 years or younger. Unlike other sports and recreational activities, there were few demographic-based injury differences, possibly due to standardization in the activity and similar exposure to risk factors.

RESULTS

To determine whether types of tubing injuries differed among different demographics, we analyzed water tubing injury data from the National Electronic Injury Surveillance System (NEISS) database that included 62,803 injuries. The NEISS database represents all injuries reported at emergency departments in the United States

We asked whether the number of injuries differed between males and females, and between individuals ages 0-19 years and 20 years or older. The national estimates of injuries between the sex and age groups were similar, with no real differences observed between them (Overlap at 95% CI, **Figure 1** and **Figure 2**). The national estimate for male was 22,809-36,962, and the national estimate for female was 25,223-40,612. The national estimate for 0-19 was 20,415-35,198, and the national estimate for 20+ was 26,781-43,212. Next, we found the national estimates for the anatomical regions of injuries and diagnoses, which were key variables used to compare injury patterns between the sex and age groups. We analyzed injury patterns by looking at the number of injuries by classification. The "all of body" classification primarily represented emergency department (ED) visits related to sunburn (95% CI, **Figure 3**). There were more head/neck injuries (17,031-27,304) than trunk injuries (8,303-15,242), and the "all of body" classification had the lowest national estimate, at 948-2,548 (95% CI, **Figure 3**). There were more sprain/strain injuries (8,504-14,238) than internal

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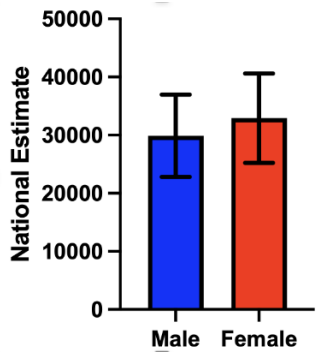

Figure 1. Water tubing injuries in males and females. National estimates with 95% confidence intervals lower and upper bounds for the national estimates. We submitted two NEISS queries for U.S. emergency department visits following water tubing injuries from 2014-2023, one for male participants and one for female participants.

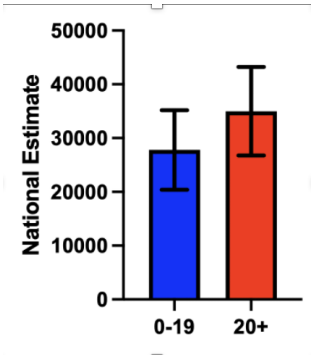

Figure 2. Water tubing injuries in children/adolescents and adults. National estimates and 95% CI lower and upper bounds for the national estimates. We submitted two NEISS queries for U.S. emergency department visits following water tubing injuries from 2014-2023, one for participants aged 0-19 and one for participants aged 20+.

organ injuries (3,965-7,737), concussions (3,362-6,469), and lacerations (4,337-7,854) (95% CI, **Figure 4**). There were more fractures than concussions (95% CI, **Figure 4**). Some participants had multiple injured anatomical regions and/or diagnoses, and the query recorded all of the injured anatomical regions and diagnoses.

After collecting total injury estimates, we compared injury patterns between males and females and between individuals ages 0-19 years and 20 years or more. The all body/unknown classification had to be excluded due to low, unreliable estimates as stated by NEISS (6). There were no statistically significant differences between the estimates for male and female participants (95% CI, **Figure 5**). However, participants aged 20 and older had more trunk and lower extremity injuries than participants aged 0-19 (95% CI, **Figure 6**).

Finally, we found the national estimates for the injury diagnoses of the demographic groups. We submitted a total of 28 NEISS queries for water tubing over a 10-year period, each selecting a diagnosis, sex, and age group. There were no differences between the diagnosis estimates for sex (95% CI, **Figure 7**). For age, the 20+ age group had more injuries with a diagnosis classified as "other" than the 0-19 age group (95% CI, **Figure 8**).

DISCUSSION

Tubing injuries are numerous, yet differences in the pattern of injuries among different demographics have not been studied. To address this gap in knowledge, we analyzed water tubing injury data using the NEISS database. There were no statistically significant differences in injured anatomical region and diagnosis between male and female participants. Adults (20+) had more trunk and lower extremity injuries than children and adolescents (0-19), and adults also had more injuries with a diagnosis classified as "other" (at the 95% confidence level). These findings suggest that the age or sex of a participant does not have a substantial influence on what injuries that individual is most at risk of. Our results also suggest that generalized safety measures should be

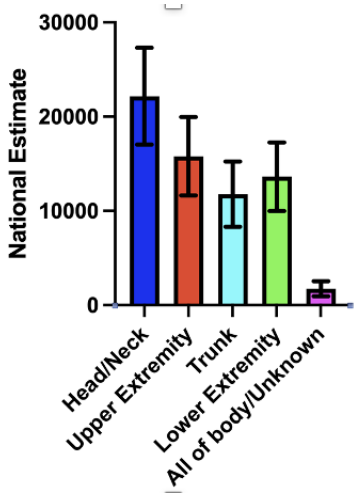

Figure 3. Injured anatomical regions in water tubing participants. National estimates and 95% CI lower and upper bounds for the national estimates. We submitted five NEISS queries for U.S. emergency department visits following water tubing injuries from 2014-2023, each selecting one anatomical region.

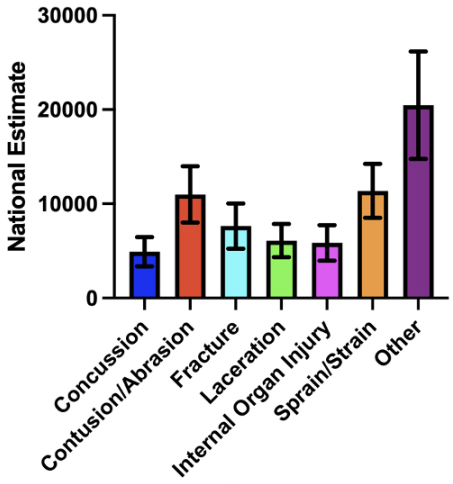

Figure 4. Diagnoses of water tubing participants. National estimates and 95% CI lower and upper bounds for the national estimates. We submitted seven NEISS queries for U.S. emergency department visits following water tubing injuries from 2014-2023, each selecting one diagnosis.

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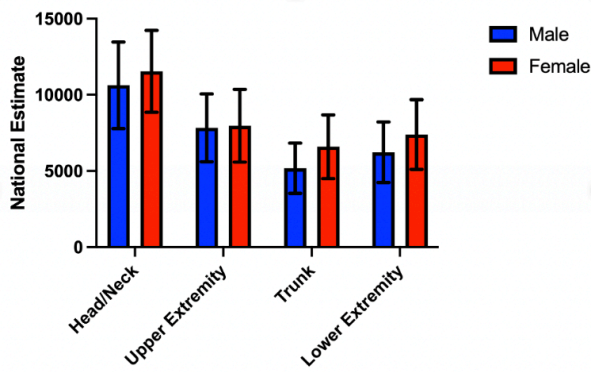

Figure 5. Injured anatomical regions in male and female water tubing participants. National estimates and 95% CI lower and upper bounds for the national estimates. We submitted a total of eight NEISS queries for U.S. emergency department visits following water tubing injuries from 2014-2023, each selecting an anatomical region and a sex.

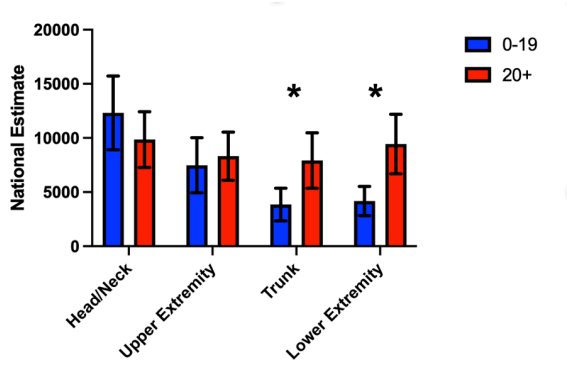

Figure 6. Injured anatomical regions in water tubing participants aged 0-19 and 20+ years. National estimates and 95% CI lower and upper bounds for the national estimates. Asterisk (*) = difference. We submitted a total of eight NEISS queries for U.S. emergency department visits following water tubing injuries from 2014-2023, each selecting an anatomical region and an age group.

made for all water tubing participants rather than specialized safety measures based on the participant's sex and age. This could possibly consist of improved handles and increased stability for inflatables to lower the risk of a severe collision with the water and increased distance between participants in inflatables designed to hold more than one person to lower the risk of collision with another participant.

The main factor that influenced the results in this study was the range between the 95% CI lower and upper bounds. If the range was smaller, it is possible that there would have been more statistically significant differences that could have provided more evidence to support the hypothesis. Despite this limitation, a coefficient of variation (CV) less than 0.30 is generally considered acceptable, and the highest coefficient of variation with the confidence intervals in these data was 0.24 (7). Another limitation with this study, and an inherent limitation with the NEISS database, is that the results of this study are only applicable to water tubing injuries seen at U.S. EDs. The database excludes injuries seen in other healthcare settings, such as primary care and urgent care. The types and severity of injuries seen in those settings may differ from those in the ED, which limits the generalizability of this study's findings.

The relative similarity in injury patterns between different demographics is contrary to the general pattern of there being demographic differences in sports injuries (4,5). There are a few possible reasons why this was the case. Water tubing is a recreational activity where the rules are the same regardless of sex or age, unlike other sports and activities. The standard safety rules are applied to and followed by all participants, which could be a factor in why the differences in injuries were not significant. Another possible factor could be similar exposure to risk factors, as all participants are exposed to the dangers of falling off the tube and colliding with other participants at similar rates. Despite the overall indication of similar injury patterns between different demographics, the differences between age groups found in this study match prior research on water tubing injuries. A previous study also found adults (20+) to have had more lower extremity injuries, despite the study using data from 1991 to 2009 (3). The findings of our study match the findings of prior studies and provide more validation to the data in the field.

Potential future studies could analyze water tubing injuries seen in other healthcare settings and determine if the results match the findings of this study and prior studies in the field. This would address the limitation present with NEISS database studies and potentially provide additional evidence to support existing claims from those studies.

We did not find many statistically significant differences in injury patterns between demographics. Our study suggests that a participant's demographic does not have a substantial influence on injury type and that generalized safety measures should be implemented for water tubing rather than demographic-specific ones. These findings differ from those of other sports and recreational activities and provide more evidence to support existing conclusions in the field.

MATERIALS AND METHODS

Sample source

The National Electronic Injury Surveillance System (NEISS) database is a collection of injury cases from a select group of U.S. emergency departments that can represent all emergency departments nationally (8). We used NEISS injury reports from 2014-2023 with the product code for water tubing (3200), and there were a total of 1,282 cases in the sample.

Querying the NEISS database

NEISS queries are the method of extracting data from the NEISS database, and they allow for the filtration of injuries by product code, injury characteristics, and participant demographic characteristics. To conduct our first test, we submitted a NEISS query for injury reports from 2014 to 2023 with the product code for water tubing (3200), and included all sexes, ages, anatomical regions, diagnoses, and dispositions. We selected national estimate and 95% confidence interval of estimate as the output measures for the query.

To conduct our second test, we submitted four NEISS queries with the same criteria; however, each query selected one of the demographic groups: male, female, ages 0-19 years, and ages 20+. We selected the same output measures as the first test. We logged each query result in the same fashion. Although there were a few participants in the sample under the age of 5, the vast majority of participants aged 0-19 were 5 years old and above.

To conduct our third test, we submitted five NEISS queries

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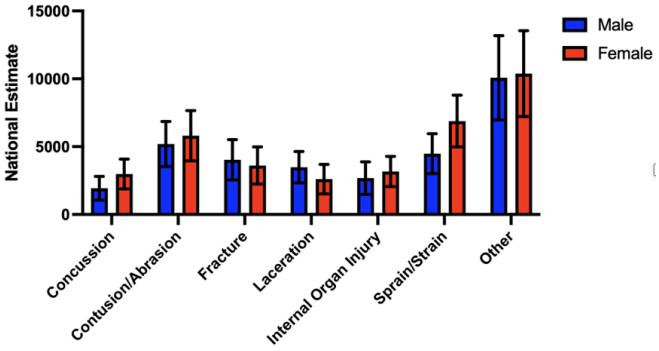

Figure 7. Diagnoses of male and female water tubing participants. National estimates and 95% CI lower and upper bounds for the national estimates. We submitted a total of fourteen NEISS queries for U.S. emergency department visits following water tubing injuries from 2014-2023, each selecting a diagnosis and a sex.

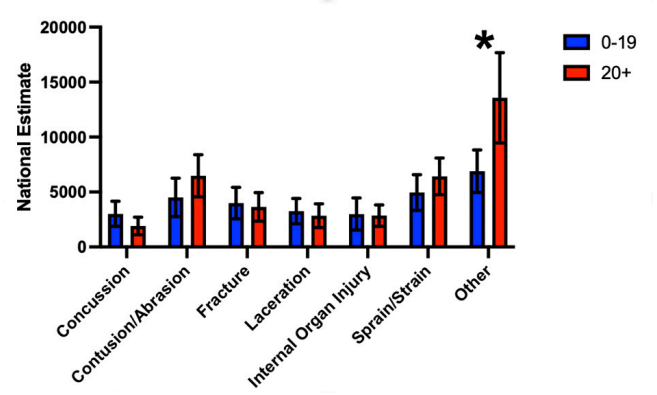

Figure 8. Diagnoses of water tubing participants aged 0-19 and 20+ years. National estimates and 95% CI lower and upper bounds for the national estimates (* = true difference between age groups). We submitted a total of fourteen NEISS queries for U.S. emergency department visits following water tubing injuries from 2014-2023, each selecting a diagnosis and an age group.

with the same criteria; however, each query selected one of the anatomical regions: head/neck, upper extremity, trunk, lower extremity, and all of body/unknown. We then submitted seven NEISS queries for concussion, contusion/abrasion, fracture, laceration, internal organ injury, sprain/strain, and "other", respectively. We selected the same output measures, and logged the query as was done previously.

To conduct our fourth test, we submitted eight NEISS queries, each selecting a sex and injured anatomical region. We then submitted another eight NEISS queries, each selecting an age group (0-19 years or 20+) and an anatomical region. The 'all of body/unknown' classification was excluded from comparison because the national estimate was too low to be statistically reliable, as stated by NEISS (6). We selected the same output measures and logged the query in the same way.

To conduct our fifth test, we submitted fourteen NEISS queries, each selecting a sex and a diagnosis. We then submitted another fourteen NEISS queries, each selecting an age group and a diagnosis. We selected the same output measures and used the same logging strategy.

Data and statistical analysis

Graphs were made using the GraphPad Prism 10 software. We entered the national estimates and their 95% confidence interval bounds that we had recorded on the google sheet into a data spreadsheet in the software. If there was no overlap between 95% confidence intervals, then we considered there to be a true difference between the compared groups.

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REFERENCES

1. "U.S. Americans Who Practiced Rafting 2021." *Statista*. www.statista.com/statistics/191255/participants-in-rafting-in-the-us-since-2006/. Accessed 29 Aug. 2024.
2. "New Study Finds Water Tubing-Related Injuries up 250 Percent." *Nationwidechildrens*. www.nationwidechildrens.org/newsroom/news-releases/2013/02/new-study-finds-water-tubing-related-injuries-up-250-percent. Accessed 29 Aug. 2024.
3. Heinsimer, Kevin R., et al. "Water Tubing-Related Injuries Treated in US Emergency Departments, 1991-2009." *Journal of Physical Activity and Health,* vol. 10, no. 2, Feb. 2013, pp. 151-159, https://doi.org/10.1123/jpah.10.2.151.
4. "Gender and Sports Injuries" *Mufaddal Gombera*. https://gomberamd.com/blog/how-does-gender-effect-sports-injuries-22576.html. Accessed 29 Aug. 2024.
5. "Age Matters Treating Sports Injuries." *UW Health.* www.uwhealth.org/news/age-matters-treating-sports-injuries-in-the-young-and-old-requires-a-thoughtful-approach#. Accessed 29 Aug. 2024.
6. "CPSC NEISS On-Line Query System." *CPSC.* www.cpsc.gov/cgibin/NEISSQuery/home.aspx. Accessed 29 Aug. 2024.
7. Sedivy, Petr, et al. "In Vitro 31P MR sChemical Shifts of in Vivo-Detectable Metabolites at 3T as a Basis Set for a Pilot Evaluation of Skeletal Muscle and Liver 31P Spectra with LCModel Software." *Molecules*, vol. 26, no. 24, 14 Dec. 2021, pp. 7571–7571, https://doi.org/10.3390/molecules26247571.
8. "National Electronic Injury Surveillance System (NEISS)." *CPSC.* www.cpsc.gov/Research--Statistics/NEISS-Injury-Data. Accessed 29 Aug. 2024.