

Injury Profile of Mixed Martial Arts Competitions in the United States

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Background: The popularity of mixed martial arts (MMA) continues to grow in the United States. Although prior work has provided valuable insight concerning injuries in the sport, much of the available literature is limited by factors such as small sample sizes, varying athlete demographics, and inconsistent data collection methods.

Purpose: To report injury rates and types in MMA and analyze potential variance between competition and match variables.

Study Design: Descriptive epidemiology study.

Methods: We performed a retrospective review of injuries sustained by fighters during MMA contests between 2018 and 2019 using ringside physician postmatch injury reports from Wisconsin and Arizona. The prevalence of overall injuries and specific injury types was compared by location (Arizona vs Wisconsin), competition level (amateur vs professional), match result (decisions vs any other result), and match winners versus losers.

Results: In 503 contests, 285 (57%) had at least 1 injury. In these 285 matches, participants experienced 401 injuries: 197 (49%) in professional bouts and 204 (51%) in amateur bouts. The match injury rate was higher in professional bouts than in amateur contests (68% vs 51%; $P < .001$). Amateur fighters had more contusions and hematomas (31% vs 22%; $P < .001$), while professional fighters had more lacerations (39% vs 23%; $P < .001$). Losers exhibited a higher match injury rate than winners (48% vs 24%; $P < .001$). Winners experienced a higher proportion of fractures (19% vs 9%; $P = .005$), and losers experienced more concussions (17% vs 2%; $P < .001$).

Conclusion: Professional fighters and losers of MMA bouts exhibited higher injury rates relative to amateurs and winners. The prevalence of specific injury types varied by competition level, match result, and match winners versus losers. The results of this study may be used to better understand the current injury profile in MMA and to develop targeted strategies for injury prevention.

Keywords: martial arts; medical aspects of sports; epidemiology; general sports trauma

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Mixed martial arts (MMA) has been practiced since ancient Greece,^{5,13} although the sport first gained significant traction in the United States in 1993 with the establishment of the first Ultimate Fighting Championship (UFC).¹ Today, professionally sanctioned MMA events are governed under a set of unified rules established by the Association of Boxing Commissions. The rules are actively enforced by a referee, and winners are declared by knock-out (KO), technical KO (TKO), submission, judge's decision, physician stoppage, referee stoppage, or disqualifications; draws and no contests are additional potential results. Amateur fights consist of 3 rounds that last 3 minutes each, and professional fights consist of 5 rounds that last 5 minutes each.^{11,21} Fighters are separated and paired according to sex (male or female), weight, and similar winning percentage. Further rules outline appropriate fight attire and legal versus illegal tactics that competitors can use.¹¹

As the popularity of MMA has continued to grow in the United States and abroad, so too has the prevalence of MMA-related injuries.⁸ Previous literature has reported mixed results: some data suggest that the rate of injury is between 23% and 29% of all fights,¹ while a survey of Brazilian jiu-jitsu athletes found that 60% of respondents were injured during competition.¹⁶ Given the inherent violent nature of MMA, these athletes may be at a high risk of sustaining an injury in any given competition. Previous reports have suggested that between 38% and 48% of all MMA injuries involve the head and neck area.^{1,17} Given the recent attention to the relationship between repeat head trauma and chronic traumatic encephalopathy,¹⁴ it is important to better understand the type and frequency of MMA injuries to maximize athletes' safety during training and competition.

Although previous research has provided valuable insight into injuries in the MMA, much of the available literature is limited in external validity, owing to factors such as the use of data that predate the establishment of unified MMA rules in 2009, reliance on survey results instead of physician reports, and inclusion of small sample sizes.^{1,15,17-19} The purpose of this study was to report and analyze injury rates and the prevalence of particular injury types within MMA and to determine how they vary between levels of competition, match outcomes, and match winners and losers.

METHODS

This study was a retrospective review using injury and bout data obtained from ringside physician reports. Based on publicly available data, it was determined that 18 US states sanctioned an amateur or professional MMA fight between 2018 and 2019: Arizona, California, Colorado, Florida, Idaho, Illinois, Kansas, Missouri, Massachusetts, Nebraska, Nevada, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Texas, and Wisconsin. State athletic commissions (the administrative bodies responsible for licensing, sponsoring, and sanctioning professional MMA events) were contacted via email and/or phone to ascertain willingness to provide injury data for MMA fights between 2018 and 2019. Additionally, we contacted the UFC Performance Institute, which is responsible in part for "reducing 'preventable' illness and injuries by offering holistic interventions that minimize susceptibility to time-loss incidents."⁶

The following data were extracted from provided records and imported into a central spreadsheet: event location, level of competition (amateur vs professional), injury type, injury location, individual win or loss (ie, if the competitor won or lost the bout), and match result (KO, TKO, decision, submission, etc). Of note, a KO is called when a fighter is no longer able to defend himself or herself, usually because of loss of consciousness, whereas a TKO is called when a third party (a referee, coach, ringside physician, etc) deems that a fighter has stopped actively defending himself or herself. TKOs and KOs were analyzed as the same result (TKO/KO), reflecting the reporting methods of the ringside injury forms. "Injury" was defined as any injury documented by the ringside physician and described with adequate

TABLE 1
MMA Match Records for 2018-2019 Provided by the Wisconsin and Arizona Gaming Commissions^a

	Wisconsin	Arizona	Overall
Total fights	242 (48)	261 (52)	503 (100)
Professional	55 (23)	112 (43)	167 (33)
Amateur	187 (78)	149 (57)	336 (67)
Decision	81 (34)	74 (28)	155 (31)
TKO/KO	87 (36)	102 (39)	189 (38)
Submission	69 (29)	84 (32)	153 (30)
No contest	4 (2)	0 (0)	4 (1)
Draw	1 (0)	1 (0)	2 (0)

^aData are reported as No. (%). KO, knockout; MMA, mixed martial arts; TKO, technical knockout.

specificity. All injuries with adequate specificity were categorized into 1 of 8 types: dyspnea, contusion/hematoma, bone fracture or cartilage injury, laceration, concussion, epistaxis, tendon/ligament injury, or muscle strains/tears.

The prevalence of overall injuries and specific injury types was reported generally for the entire sample and by each of the aforementioned independent variables. Two statistical comparisons were performed, both using a chi-square test with significance set at $P < .05$. Injury prevalence within a particular group was defined as an injury rate, and injury rates were compared by state, level of competition (amateur vs professional), match result (match decision vs any other result), and match winners versus losers. The prevalence of specific injury types was also compared according to the same categories.

RESULTS

Commissions from 16 states either failed to respond to initial inquiries or declined to participate, and the UFC Performance Institute also declined to participate. Officials from 2 states, Arizona and Wisconsin, agreed to provide injury data for this study. Public record requests were submitted to both athletic commissions to obtain injury data between 2018 and 2019 from MMA contests in those states. Injury data were recorded by ringside physicians immediately after each fight using standardized postmatch injury forms. In accordance with the Health Insurance Portability and Accountability Act, the commissions provided us with deidentified postmatch injury reports for the winners and losers of 503 MMA contests: 242 in Wisconsin and 261 in Arizona (Table 1).

Injury Profile in MMA Competitions

Of the 503 contests, 285 (57%) had at least 1 reported injury, with 115 (40%) occurring in Wisconsin and 170 (60%) in Arizona. Of the 285 bouts with an injury, 40% (114/285) were professional and 60% (171/285) were amateur. Furthermore, in the 285 matches that resulted in an injury, participants experienced 401 total unique injuries, with 197 (49%) occurring in professional bouts and 204

(51%) in amateur bouts. The most common type of injury reported was a laceration, which represented 30% (122/401) of total unique injuries. Professional bouts exhibited an injury rate of 68% (114/167), while amateur bouts had an injury rate of 51% (171/336) ($P < .001$). Contusions and hematomas constituted 31% (63/204) of injuries sustained by amateur fighters and 22% (43/197) sustained by professional fighters ($P < .001$). Epistaxis composed 8% (16/204) of injuries experienced by amateurs and only 2% (3/197) by professionals ($P = .004$). Concussions accounted for 16%

(32/204) of injuries among amateurs and 9% (17/197) among professionals ($P = .041$). Conversely, lacerations accounted for 39% (76/197) of injuries sustained by professionals and 23% (46/204) sustained by amateurs ($P < .001$). Finally, bone and cartilage fractures represented 16% (31/197) of injuries experienced by professionals and 9% (19/204) by amateurs ($P = .039$).

Injury rates for MMA bouts are outlined in Table 2. Across all contests, losers exhibited an injury rate of 48% (239/503), whereas winners exhibited an injury rate of 24% (119/503; $P < .001$). The injury rate of losers remained higher in individual analyses of professional and amateur bouts. Losers of professional bouts displayed an injury rate of 59% (98/167), while winners had an injury rate of 36% (60/167) ($P < .001$). Amateur losers exhibited an injury rate of 42% (141/336) as compared with 18% (59/336) ($P < .001$) for amateur winners. Of the 401 total unique injuries, winners experienced 131 (33%) and losers 270 (67%) (Table 3). Relative to total injuries sustained by winners and losers (Table 4), fractures represented 19% (25/131) among winners and 9% (25/270) among losers ($P = .005$). Concussions constituted 17% (47/270) of injuries experienced by losers and only 2% (2/131) by winners ($P < .001$).

The injury rate of bouts ending by decision was 56% (88/155), and that ending by TKO/KO, no contest, or submission was 57% (197/346; $P = .912$). However, contusions and hematomas represented 34% (48/143) of injuries in matches ending by decision and 22% (57/258) by all other outcomes ($P = .015$). Furthermore, concussions accounted for 3% (4/143) of injuries in matches ending by decision versus 18% (45/258) by all other outcomes ($P < .001$) (Table 4). In matches ending by TKO or KO, losers experienced an injury rate of 65% (122/189) as compared with 24% (44/189) for winners ($P < .001$). In matches ending by submission, losers had an injury rate of 31% (48/153) and winners 15% (23/153) ($P < .001$).

Wisconsin vs Arizona

The rate of matches ending with at least 1 injury (Table 5) in Arizona was 65% (170/261), which was significantly higher than the 48% (115/242) in Wisconsin ($P < .001$). Higher injury rates were observed in Arizona in amateur contests, professional contests, and matches ending by decision and TKO/KO. In Arizona, professional bouts exhibited

TABLE 2

Statistical Analysis of Injury Rate for All MMA Bouts in Wisconsin and Arizona During the 2018-2019 Season^a

Comparison	n1	n2	P Value
Professional vs amateur (n1 vs n2)	114 (68)	171 (51)	<.001
Loser vs winner (n1 vs n2)			
Overall	239 (48)	119 (24)	<.001
Decision	66 (42)	52 (33)	.102
TKO/KO	122 (65)	44 (24)	<.001
Submission	48 (31)	23 (15)	<.001
Professional	98 (59)	60 (36)	<.001
Amateur	141 (42)	59 (18)	<.001
Decision vs all other (n1 vs n2)	88 (56)	197 (57)	.912

^aData are reported as No. (%). Bold indicates $P < .05$. KO, knockout; MMA, mixed martial arts; TKO, technical knockout.

TABLE 3

Total Unique Injuries Sustained by MMA Fighters^a

	Wisconsin	Arizona	Overall
Total unique injuries	136 (34)	265 (66)	401 (100)
Professional	51 (38)	146 (55)	197 (49)
Amateur	85 (63)	119 (45)	204 (51)
Winner	37 (27)	94 (35)	131 (33)
Loser	99 (73)	171 (65)	270 (67)
Decision	47 (35)	96 (36)	143 (36)
TKO/KO	61 (45)	124 (47)	185 (46)
Submission	25 (18)	45 (17)	70 (17)
No contest	3 (2)	0 (0)	3 (1)

^aData are reported as No. (%). KO, knockout; MMA, mixed martial arts; TKO, technical knockout.

TABLE 4

Comparison of Injury Types Relative to Total Injuries in All MMA Bouts^a

Injury Type	Professional	Amateur	P	Winner	Loser	P	Decision	All Other Outcomes	P
Dyspnea	1 (0.5)	4 (2)	.202	1 (0.8)	4 (1.5)	.543	1 (0.7)	4 (1.6)	.455
Contusion, hematoma	43 (21.8)	63 (30.9)	<.001	34 (26)	72 (26.7)	.879	48 (33.6)	57 (22.4)	.015
Bone, cartilage fracture	31 (15.7)	19 (9.3)	.039	25 (19.1)	25 (9.3)	.005	18 (12.6)	32 (12.6)	.991
Tendon, ligament injury	20 (10.2)	18 (8.8)	.579	16 (12.2)	22 (8.2)	.192	18 (12.6)	19 (7.5)	.090
Laceration	76 (38.6)	46 (22.6)	<.001	46 (35.1)	76 (28.2)	.155	44 (30.8)	77 (30.2)	.905
Concussion	17 (8.6)	32 (15.7)	.041	2 (1.5)	47 (17.4)	<.001	4 (2.8)	45 (17.7)	<.001
Epistaxis	3 (1.5)	16 (7.8)	.004	3 (2.3)	16 (5.9)	.108	7 (4.9)	12 (4.7)	.932
Muscle strain/tear	6 (3.1)	6 (2.9)	.908	4 (3.1)	8 (3)	.960	3 (2.1)	9 (3.5)	.423

^aData are reported as No. (%). Bold indicates $P < .05$. MMA, mixed martial arts.

TABLE 5
Statistical Comparison of the Rate of Matches Ending
in at Least 1 Injury in Wisconsin and Arizona^a

Match Injury Rate	Wisconsin	Arizona	P Value
Overall	115 (48)	170 (65)	<.001
Professional	30 (55)	84 (75)	.008
Amateur	85 (45)	86 (58)	.025
Decision	36 (44)	52 (70)	<.001
TKO/KO	51 (59)	83 (81)	.001
Submission	25 (36)	35 (42)	.490

^aData are reported as No. (%). Bold indicates $P < .05$. KO, knockout; TKO, technical knockout.

an injury rate of 75% (84/112) and amateur bouts 58% (86/149); in Wisconsin, professionals bouts had an injury rate of 55% (30/55; $P = .008$) and amateur bouts 45% (85/187; $P = .025$). The injury rate of bouts ending by decision was 70% (52/74) in Arizona and 44% (36/81) in Wisconsin ($P < .001$), and that ending by TKO/KO was 81% (83/102) in Arizona and 59% (51/87) in Wisconsin ($P = .001$).

Of the 401 unique injuries experienced by athletes, 136 (34%) occurred in Wisconsin and 265 (66%) in Arizona (Table 3). The most common injury reported was laceration in both states, representing 30% (80/265) of injuries in Arizona and 31% (42/136) in Wisconsin. Relative to total unique injuries (Figure 1), cases of dyspnea represented 2.9% (4/136) of injuries in Wisconsin and 0.4% (1/265) in Arizona ($P = .0285$), and epistaxis constituted 9.6% (13/136) of injuries in Wisconsin and 2.3% (6/265) in Arizona ($P = .011$). Bone and cartilage fractures represented 15.9% (42/265) of injuries sustained in Arizona and 5.9% (8/136) in Wisconsin ($P = .0042$).

DISCUSSION

The primary goal of the present study was to identify current injury trends in MMA competition using recent data. Of the 503 MMA bouts included in the present study, 285 (57%) involved an injury, and fighters sustained a total of 401 unique injuries. Professional bouts (68%) had a significantly higher injury rate than amateur bouts (51%). Losers of MMA bouts (48%) experienced a significantly higher injury rate than winners (24%). There was no significant difference between the injury rates of bouts ending by decision and bouts ending in all other outcomes. Additionally, we found that the injury rate in MMA bouts was higher in Arizona than in Wisconsin and that the frequency of certain injury types (eg, dyspnea, fractures, and epistaxis) varied significantly between the states. However, given the lack of controlled injury reporting methods in the provided data, these state-versus-state comparisons should be interpreted with caution.

Within MMA literature, a fight-participation is defined as 1 athlete's experience of 1 fight, and it is used to calculate injury rates relative to the number of participants rather than the number of bouts. The injury rate identified in the present study was approximately 40 injuries per 100

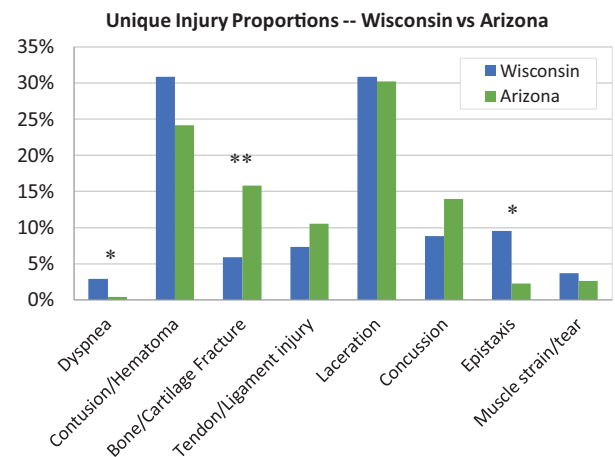


Figure 1. Comparison of injury proportions between Arizona and Wisconsin. Fx, fracture. * $P < .05$. ** $P < .005$.

fight-participations, which is notably higher than the injury rates of other combat sports, such as boxing (25 per 100 fight-participations) and kickboxing (11 per 100 fight-participations).^{22,23} In a recent study about MMA injuries, Fares et al⁴ identified a slightly higher injury rate of 51 per 100 fight-participations. A similar study by Jensen et al⁸ reported an injury rate of 22.9 to 28.6 per 100 fight-participations. The discrepancies in injury rates may be attributed to differences in available data and study design. MMA combines techniques from various martial arts disciplines and combat sports in a setting with fewer restrictions on what each athlete can do in a match. The inherent nature of MMA may explain its higher injury rate as compared with other combat sports.^{10,20}

In the current study, there was at least 1 documented injury in 57% (285/502) of total bouts. All 401 reported injuries occurred in these 285 bouts, yielding an average of 1.41 injuries per match with an injury. This finding is similar to that reported in previous studies. Bledsoe et al¹ found that 40.3% (69/171) of matches between 2001 and 2004 involved at least 1 injury, for a total of 96 injuries. This translated to a mean 1.39 injuries in each of the 69 matches with an injury. McClain et al¹³ found that 121 injuries occurred in 115 of 711 (16.2%) total bouts, for a mean 1.05 injuries in each bout with at least 1 reported injury.

Prior studies have demonstrated that losers of MMA contests are disproportionately affected by injury. Lystad et al¹² evaluated injuries sustained by professional MMA fighters and found that losers incurred 3 times as many injuries as winners. Bledsoe et al¹ analyzed the injury rates of professional MMA fighters in Nevada and similarly concluded that losers were significantly more likely to experience an injury than the winners of an MMA bout, regardless of match result. In a multivariate logistic regression, Ngai et al¹⁵ demonstrated that a loser of a professional MMA bout was 2.4 times more likely to be injured than a winner, independent of athlete demographics and fight result. The findings of the current study largely agree with prior data: losers had 67% (270/401) of the total unique injuries, double the 33% (131/401) experienced by winners.

Furthermore, injury rates were significantly higher for losers in professional contests, amateur contests, matches ending by TKO/KO, and matches ending by submission.

Head trauma is a common injury in MMA. A retrospective analysis of 642 MMA bouts found that 182 (28.3%) were stopped because of a strike to the head, resulting in 62 (34%) KOs and 120 (66%) TKOs.² This rate of match stoppage attributed to head trauma is higher than that of boxing (8.8%) and kickboxing (7.7%).² In a similar analysis, Hutchison et al⁷ concluded that the incidence of traumatic brain injuries within MMA is 15.9 per 100 athlete-exposures, which is higher than the rates seen in American football (8.08 per 100 athlete-exposures) and hockey (2.2 per 100 athlete-exposures). In a retrospective study, Curran-Sills and Abedin³ reported that losers of MMA matches sustained 86% of total injuries. Additionally, 101 of 162 total injuries (62%) were concussions, and 94 (93%) of those occurred in matches ending by TKO/KO. Those authors did not find level of competition to be associated with risk of sustaining a concussion. In the present study, concussions accounted for a greater proportion of all injuries sustained by losers as compared with winners. Losers experienced 96% (47/49) of the reported concussions, and 90% (44/49) of these concussions occurred during a match ending by TKO/KO. These findings align with previous research in suggesting that MMA fighters who lose by TKO/KO are at a severely high risk of sustaining head trauma. We also found that amateurs experienced significantly more concussions than professionals. Insufficient evidence in the literature exists to conclusively support or refute this finding, and future investigations should focus on comparing the injury epidemiology of amateurs and professionals.

While similar proportions of total unique injuries occurred in amateur fights (51%) and professional fights (49%), the injury rate of professional fights was 68% (114/167), and that of amateur fights was 51% (171/336) ($P < .001$). This finding is similar to previous studies, with the purported explanations being that professional bouts last longer than amateur bouts, professional fighters are less likely to succumb to submissions, and professional fighters are permitted to use elbow strikes.^{13,17} The present analysis identified that professional fighters experienced a greater proportion of lacerations and amateurs experienced a greater proportion of contusions and hematomas relative to total injuries. McClain et al¹³ reported that professional fighters were twice as likely to sustain lacerations than amateurs. While the reasons behind these differences are unclear, lacerations and contusions have been reported to be the most common injuries sustained by MMA athletes.^{12,17} With the high incidence of bleeding in MMA, the transmission risk of bloodborne diseases would seem to be much more serious than in other sports. However, such transmission has been rare, and most organizations enact appropriate blood precautions before MMA events, including testing and vaccination.⁹ Contestants may bleed without referee intervention during a round, but if the bleeding is severe or cannot be controlled between rounds, the referee or ringside physician will stop the fight.¹¹

In our study, no significant differences in injury rate were seen between matches ending by decision and matches ending by all other outcomes. This finding contrasts the trends commonly reported in MMA literature. Matches ending by TKO/KO have been associated with a significantly higher injury rate than matches ending by decision or submission.^{4,13} Furthermore, fighters of matches ending by decision reportedly experience twice as many injuries as fighters of matches ending by submission, possibly because of the increased time spent fighting.¹² A previous study suggested that each minute spent in an MMA match increases the likelihood of injury by 4.2%.¹⁵ More data-driven research is needed to better understand the unique injury profiles of each match result and the specific variables driving differences in injury incidence and injury type.

There are several limitations to consider when interpreting the results of this study. Fight data were provided by gaming commissions from only 2 states, which introduces selection bias. In addition, the fight data provided by Wisconsin and Arizona varied in quantity of records, format, and types of information provided. These inconsistencies limit the external validity of comparisons of injury data from the 2 states, as well as the application of our results to MMA as a whole, given the relatively small sample size and the geographic specificity of the data. Matches ending in KO or TKO were analyzed together because much of the provided data did not discriminate between the outcomes and instead reported them as TKO/KO; however, it is possible that injury epidemiology differs between these two match results. It would tremendously improve the understanding of injury epidemiology in MMA if these results were reported separately in the future.

Interpretation of several records was complicated by incomplete data, a lack of standardized diagnoses, and unclear or illegible transcriptions (much of the provided data were in the form of scanned handwritten match result sheets). For example, if a match result record listed a participant as having sustained an "arm injury," it was excluded from the analysis given the ambiguity of the diagnosis. A complete lack of specificity was not apparent in all of the provided data, but much of the postmatch diagnoses were slightly ambiguous. These inherent flaws in the provided data were mitigated by jointly reviewing each provided record, judging if the data included adequate detail for inclusion in this analysis, and organizing all included injuries into slightly broader injury types to adequately power a statistical analysis.

Another limitation to this study is that data on fighter sex, weight class, and match length were not provided by either state. Prior research has shown that these variables contribute to differences in injury rate and prevalence; therefore, the inability to adjust for these factors in the present study may have confounded the analysis. Finally, neither short- nor long-term follow-up data were provided. From a clinical and competitive standpoint, such data would have been valuable for validating the accuracy of postoperative diagnoses and for assessing the relative impact of specific injuries on athletes in subsequent competition. The major limitations of this study affirm the need

for a national MMA injury database with standardized reporting methods to be adopted by all professional and amateur administrative bodies for the benefit of researchers and athletes alike.

CONCLUSION

The present study found that a majority of MMA bouts ended with at least 1 participant sustaining an injury. The most common match result was TKO/KO, and the largest proportion of injuries occurred in matches ending by TKO/KO. Injury rates were significantly higher in professional bouts than in amateur bouts and in losers versus winners. The results of this study may be used to better understand the current injury profile in MMA and thus develop targeted strategies for injury prevention. Future prospective studies are warranted using larger samples and standardized reporting methods.

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