

Sleep-Related Infant Suffocation Deaths Attributable to Soft Bedding, Overlay, and Wedging

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abstract

BACKGROUND: Unintentional suffocation is the leading cause of injury death among infants <1 year old in the United States, with 82% being attributable to accidental suffocation and strangulation in bed. Understanding the circumstances surrounding these deaths may inform prevention strategies.

METHODS: We analyzed data from the population-based Sudden Unexpected Infant Death Case Registry from 2011 to 2014. Cases categorized as explained suffocation with unsafe sleep factors (suffocation), per the Centers for Disease Control and Prevention's Sudden Unexpected Infant Death Case Registry classification system, were included and assigned a mechanism of obstruction, including soft bedding, overlay, or wedging. We calculated frequencies and percentages of suffocation deaths by mechanism and selected demographic and sleep-environment characteristics.

RESULTS: Fourteen percent of sudden unexpected infant death cases were classified as suffocation; these cases were most frequently attributed to soft bedding (69%), followed by overlay (19%) and wedging (12%). Median age at death in months varied by mechanism: 3 for soft bedding, 2 for overlay, and 6 for wedging. Soft-bedding deaths occurred most often in an adult bed (49%), in a prone position (82%), and with a blanket (or blankets) obstructing the airway (34%). Overlay deaths occurred most often in an adult bed (71%), and infants were overlaid by the mother (47%). Wedging deaths occurred most often when the infant became entrapped between a mattress and a wall (48%).

CONCLUSIONS: Safe sleep environments can reduce infant suffocation deaths. Increased knowledge about the characteristics of suffocation deaths can help inform prevention strategies by targeting highest-risk groups.



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WHAT'S KNOWN ON THIS SUBJECT: Unintentional suffocation is the leading cause of injury death among US infants, with 82% attributable to accidental suffocation and strangulation in bed. These deaths are preventable. In Sudden Unexpected Infant Death Case Registry data, airway obstruction is differentiated by mechanism.

WHAT THIS STUDY ADDS: Soft-bedding deaths occur more than overlay and wedging deaths. Suffocation by pillows occurs twice as often among infants ≤4 months old. If suffocation deaths had been prevented during the study period, the US sudden unexpected infant death rate would have dropped below the Healthy People 2020 goal.

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Unintentional suffocation is the leading cause of injury death among infants (<1 year old) in the United States.¹ Eighty-two percent of unintentional infant suffocation deaths are attributed to accidental suffocation and strangulation in bed (ASSB). According to US death-certificate data, rates of infant deaths reported as ASSB per 100 000 live births have increased nearly fourfold, from 6 deaths in 1999 to 23 deaths in 2015.² This increase is at least partly attributed to changing diagnostic preferences and improved death investigations.² These injury deaths, often resulting from hazards in the sleep environment, are preventable. Historically, surveillance of infant sleep-related suffocation deaths has relied on underlying cause-of-death codes that are assigned on the basis of the cause of death from death certificates. However, death certificates do not systematically collect information about the circumstances of death. Differentiating a death caused by suffocation from other causes of sudden unexpected infant death (SUID), such as sudden infant death syndrome (SIDS), relies on detailed information from the death-scene investigation and autopsy, for which practices are not standard across jurisdictions.³ Furthermore, variations are known to exist in diagnostic preferences and the levels of evidence death certifiers use to designate suffocation as a cause of death, leading to a diagnostic shift in SUID from SIDS to ASSB.²⁻⁵

In 2009, the Centers for Disease Control and Prevention (CDC) created the Sudden Unexpected Infant Death Case Registry to better understand the trends and characteristics associated with SUID, including sleep-related suffocation.⁶ The SUID Case Registry is built on existing Child Death Review programs and the National Center for Fatality Review and Prevention protocols and data system.⁷ The Case Registry is a multijurisdictional, population-based surveillance system

that monitors SUID cases using data from death-scene investigations, autopsies, medical records, and other relevant data sources. Approximately one-third of US SUID cases are captured in the Case Registry. States participating in the Case Registry receive assistance from the CDC to improve data quality, timeliness, and case ascertainment.

In 2014, the CDC developed the Case Registry classification system to consistently differentiate SUID cases into the following groups: no autopsy or death-scene investigation, incomplete case information, no unsafe sleep factors, unsafe sleep factors, possible suffocation with unsafe sleep factors, and explained suffocations with unsafe sleep factors.⁸ To understand the factors contributing to and mechanisms of suffocation deaths, the classification system requires the review of detailed information about specific circumstances of each death, including the sleep location and position when found. This information and the resulting classification are important to reliably monitor the incidence of and trends in SUID and SUID subtypes. Identifying factors contributing to suffocation deaths occurring in unsafe sleep environments addresses national and international research priorities⁹ and may help inform strategies to reduce these deaths. In this study, we describe demographic and sleep-environment characteristics of SUID cases classified as explained suffocation with unsafe sleep factors (suffocation) per the CDC's SUID Case Registry classification system. This classification requires a high level of evidence of airway obstruction, which is described in detail below.

METHODS

Using data from the CDC's SUID Case Registry,⁶ we analyzed infant deaths that occurred from 2011 through

2014 (the most recent year for which categorized Case Registry data were available) among residents of states participating in the Case Registry. Infants were defined as children <1 year old. We limited the study population to deaths classified as suffocation per the classification system.⁸ Data were derived from the states participating in the Case Registry at the time of this study, including Arizona, Colorado, Georgia, Louisiana, Michigan, Minnesota, New Hampshire, New Jersey, New Mexico, and Wisconsin. In addition to existing data-use agreements, all states agreed to the use of their deidentified aggregate data for this study.

For these analyses, the authors classified Case Registry cases using the classification system. Cases were classified as suffocation when all of the following criteria were met.⁸ First, the reported cause on the death certificate was one of the following: unknown; undetermined; SIDS; SUID; unintentional sleep-related asphyxia, suffocation, or strangulation; unspecified suffocation; cardiac or respiratory arrest without other well-defined causes; or ill-defined causes with potentially contributing unsafe sleep factors. Intentional homicides were excluded. Second, a complete death investigation documented where and how the infant was found, and a comprehensive autopsy included (at a minimum) toxicology, imaging, and pathology. Third, the infant was found unresponsive in an unsafe sleep environment with a reliable, nonconflicting witness account of a full external airway obstruction of both the nose and mouth or airway obstruction due to compression of the neck and/or chest. Finally, there were no other potentially fatal findings or concerning conditions (eg, sepsis or congenital birth defect) reported.

Using the classification system, the authors assigned each suffocation case 1 or more mechanisms to which the airway obstruction was

attributed. Mechanisms included soft bedding, overlay, wedging, and other.⁸ Soft bedding was assigned when an infant's airway was obstructed by an adult mattress, blanket, pillow, couch cushion, or other soft object in the immediate sleep environment. Wedging was assigned when an infant's airway was obstructed as the result of being trapped or compressed between inanimate objects (eg, a mattress and wall). Overlay was assigned when there was a witnessed account of a person on top of or against an infant, obstructing the infant's airway. Other was assigned only when the airway obstruction was caused by something in the sleep environment other than soft bedding, overlay, or wedging, such as a plastic bag. Cases could have been assigned >1 mechanism. For example, an infant whose nose and mouth were obstructed by soft bedding (soft bedding), and had his or her neck or chest compressed by a person (overlay).

We derived study variables from individual fields in the National Center for Fatality Review and Prevention's National Fatality Review Case Reporting System by combining information from different fields or after a qualitative review of written text.¹⁰ Selected variables were those most pertinent to the study question with the most complete information recorded. This study includes infants from birth to <1 year old. Age is reported in completed months. For example, 0 months includes infants from birth to <1 month old, and 11 months includes infants from 11 to <12 months old. Medicaid is a state and/or federal health insurance program for people with low income and is used as a proxy for socioeconomic status. Qualitative variables include object obstructing the airway, person sharing the sleep surface with the infant, person who overlaid the infant, body part that overlaid the infant, airway obstruction type, person who

overlaid was impaired by drugs or alcohol near the time he or she went to sleep with the infant, and objects infant was wedged between. In cases in which the object that obstructed the airway was an adult mattress, there may have been sheets, blankets, or other bedding materials between the adult mattress and the infant's airway. We calculated frequencies and percentages of suffocation by mechanism and selected variables, including infant demographics and sleep-environmental factors at the time of death. Per the data-use agreement with states, counts of 1 through 2 are suppressed in an effort to protect confidentiality. Analyses were conducted by using SAS for Windows version 9.3 (SAS Institute, Inc, Cary, NC).

RESULTS

Of 1812 cases in the Case Registry from 2011 through 2014, 250 (14%) were classified as suffocation per the classification system; the remaining cases were classified as unexplained SUID. Of suffocation cases, 219 were assigned 1 mechanism, and 31 were assigned 2 mechanisms. Cases with 2 mechanisms were counted in both mechanism groups; thus, 281 mechanisms were assigned to the 250 cases. Seven cases were assigned the mechanism other. The majority of these infants were suffocated by plastic bags. Because of the small size of this group, these cases are not included in the analyses by mechanism. Of the mechanisms assigned, 190 (69%) were soft bedding, 51 (19%) were overlay, and 33 (12%) were wedging (Table 1).

A majority of infants were boys, born at term (≥ 37 weeks' gestation), non-Hispanic white or African American, and insured by Medicaid (Table 1). The median age at death was 3 months, and most deaths occurred in the infant's home. The distribution of age at death varied by mechanism (Fig 1). Among soft-bedding deaths,

68% occurred from 1 through 4 months old (median = 3 months old). Among overlay deaths, 71% occurred during the first 2 months of life (median = 2 months), and no deaths occurred after 7 months. More than half (58%) of wedging deaths occurred from 5 through 8 months old (median = 6 months old). Of the 51 suffocation deaths attributed to overlay, 25% were born preterm (< 37 weeks' gestation) compared with 15% among soft bedding and 12% among wedging. Also, 49% of overlay deaths were exposed to prenatal maternal smoking compared with 36% among soft bedding and 27% among wedging.

Soft Bedding

Suffocation deaths attributed to soft bedding varied by sleep place, position found, surface-sharing status, and type of object obstructing the airway (Table 2). Among soft-bedding deaths, 49% occurred in an adult bed, and 27% occurred in a crib or bassinet (including portable cribs; Table 2). Most (92%) were found in a nonsupine position. Of the 92 infants (48%) who were found sharing a sleep surface with another person, 61 (66%) were sharing with 1 or both parents, and 24 (26%) were sharing with 1 or more siblings (these groups are not mutually exclusive, nor are data shown in tables). Of the soft objects reported as obstructing the infants' airways, 34% were blankets, 23% were adult mattresses, and 22% were pillows.

The type of object obstructing the airway differed by infant age. Infants ≤ 4 months old had their airways obstructed by pillows or couch or recliner cushions approximately twice as often as infants 5 to 11 months old (25% vs 11% for pillows; 12% vs 7% for couch or recliner cushions). Infants 5 to 11 months old had their airways obstructed by blankets approximately twice as often as infants ≤ 4 months old (55% vs 27%).

TABLE 1 Selected Characteristics of Suffocation Deaths Overall (*n* = 250) and by Mechanism (*n* = 274): 2011–2014

	Overall		Soft Bedding		Overlay		Wedging	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Overall	250		190	69	51	19	33	12
Infant sex								
Male	137	55	104	55	26	51	17	52
Female	112	45	85	45	25	49	16	48
Missing	^a	^a	^a	^a	^a	^a	^a	^a
Gestational age at birth, wk								
Preterm, <37	41	16	28	15	13	25	4	12
Term, ≥37	202	81	156	82	37	73	28	85
Missing	7	3	6	3	^a	^a	^a	^a
Infant race and/or ethnicity								
Non-Hispanic white	101	40	75	39	22	43	13	39
Non-Hispanic African American	85	34	59	31	22	43	13	39
Hispanic	41	16	36	19	4	8	^a	^a
Other, missing, or unknown	23	9	20	11	3	6	^a	^a
Infant insured by Medicaid								
Yes	176	70	130	68	44	86	19	58
No	44	18	36	19	3	6	7	21
Unknown	30	12	24	13	4	8	7	21
Location of death								
Infant's home	209	84	154	81	45	88	28	85
Friend's or relative's home	24	10	21	11	3	6	3	9
Day care	7	3	6	3	^a	^a	^a	^a
Missing or other	10	4	9	5	^a	^a	^a	^a
Exposure to prenatal maternal smoking								
Yes	89	36	69	36	25	49	9	27
No	138	55	104	55	19	37	21	64
Unknown	23	9	17	9	7	14	3	9

The overall column includes all 250 suffocation cases; cases assigned 2 mechanisms are included in the total for each of the assigned mechanisms.

^a Per the data-use agreement with states, counts of 1 through 2 are suppressed in an effort to protect confidentiality.

Overlay

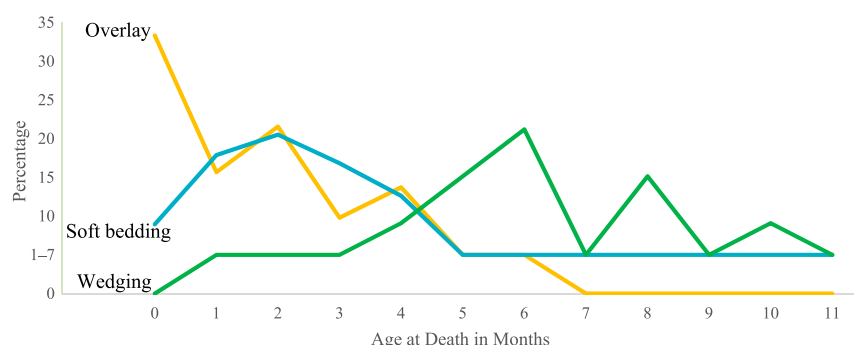
Seventy-one percent of overlay deaths occurred in an adult bed, and 51% were found nonsupine (Table 3). Of persons who overlaid these infants, 47% were the mother, 25% were the father, and 22% were a sibling. In 41% of the overlay deaths, the infant was sharing a sleep

surface with >1 person. Among overlay deaths, 7 (14%) were overlaid by the mother's breast (data not shown in tables). Most overlay deaths (71%) were attributed to neck or chest compression as opposed to obstruction of the nose and mouth (22%) or both or unknown (8%). Of the 40 overlay deaths in which an

adult overlaid the infant, 23% of the adults were reported to have been impaired by alcohol or drugs around the time they went to sleep with the infant. Among the 10 overlay deaths that occurred after an adult fell asleep while feeding the infant, 7 were breastfeeding (14% of all overlay deaths).

Wedging

Of the 33 suffocation deaths attributed to wedging, 45% were sharing a sleep surface at the time of death, and 73% occurred in an adult bed (Table 4). The objects between which the infant was wedged were most frequently a mattress and wall (48%), followed by a mattress and bed frame (including headboard; 27%). Some infants were wedged between a crib mattress and something else; these cases all involved a crib mattress used with a broken crib or a crib mattress that

**FIGURE 1**

Age distribution for each mechanism of suffocation death (2011–2014; *n* = 274). In an effort to protect confidentiality and per the data-use agreement with states, percentages in the 1% to 7% range with a numerator of 1 through 2 are all shown on the y-axis at the same level (5%).

TABLE 2 Suffocation Soft-Bedding Deaths by Age at Death and Sleep Circumstances (*n* = 190): 2011–2014

	All Ages		0–4 mo		5–11 mo	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Sleep place						
Adult bed	93	49	71	49	22	50
Crib or bassinet	51	27	41	28	10	23
Chair or couch	26	14	22	15	4	9
Other	20	11	12	8	8	18
Position found						
Prone	155	82	126	86	29	69
Side	19	10	10	7	9	21
Supine	14	7	10	7	4	10
Sharing a sleep surface with another person						
No	95	50	69	47	26	59
Yes	92	48	75	51	17	39
Unknown	3	2	^a	^a	^a	^a
Object obstructing airway						
Blanket(s)	64	34	40	27	24	55
Adult mattress	44	23	35	24	9	20
Pillow	42	22	37	25	5	11
Couch or recliner cushion	20	11	17	12	3	7
Multiple objects	10	5	^a	^a	^a	^a
Bumper pad	5	3	^a	^a	^a	^a
Other	5	3	5	3	0	0

Groups do not equal 100% because of rounding.

^a Per the data-use agreement with states, counts of 1 through 2 are suppressed in an effort to protect confidentiality.

was ill fitting or not used as recommended (eg, an infant between a crib mattress and an adult mattress that were both placed on the floor or an infant between a crib mattress and the broken rail of a drop-down crib).

DISCUSSION

From 2011 to 2014, 250 of 1812 (14%) Case Registry cases were classified as suffocation as defined by the classification system.⁸ Suffocation deaths were most frequently attributed to an airway obstruction by soft bedding, followed by overlay and wedging. These deaths represent a small proportion of all SUID cases, but safe sleep environments can prevent suffocation deaths. From 2011 to 2014, the US SUID rate was 87 deaths per 100 000 live births, according to National Center for Health Statistics data.¹¹ If the number of deaths proportionally equivalent to the 14% of Case Registry cases classified as suffocation from 2011 through 2014 had been prevented, the US SUID rate would have dropped to 75 deaths per 100 000 live births,

which is below the Healthy People 2020 goal of 84.^{11,12}

Our study revealed the following commonalities and differences in characteristics of suffocation deaths stratified by mechanism of airway obstruction. Nonsupine sleep position and sleeping in an adult bed were common characteristics among deaths attributed to all 3 mechanisms. Soft-bedding deaths most commonly involved an airway obstruction by blankets. Among overlay deaths, surface sharing with the parent(s) was most common, and infants were most often overlaid by their mothers. Wedging deaths most frequently occurred when the infant became stuck between an adult mattress and a wall.

Our findings reveal that factors and mechanisms of suffocation differ by infant age. Younger infants (≤ 4 months old) were more often suffocated by overlay or soft bedding than wedging. Younger infants are less likely to get themselves into a wedged position because they are less mobile and cannot roll over on

their own. Infants who were suffocated by overlay were youngest and had a higher proportion born preterm than infants who were suffocated by soft bedding or via wedging.

Among soft-bedding deaths, more than half of infants 5 to 11 months old had their airways obstructed by blankets compared with less than one-third of younger infants. Almost half of infants 5 to 11 months old whose airways were obstructed by blankets were entangled in the blankets. It is likely that these older, more developed infants were mobile enough to become entangled in blankets but were not yet coordinated enough to free themselves. Pillows caused the airway obstructions twice as often among infants ≤ 4 months old compared with infants 5 to 11 months old. Younger infants may have lacked the mobility and neck strength necessary to lift their heads to prevent an airway obstruction, especially when placed prone or on their side on a pillow.¹³

TABLE 3 Suffocation Overlay Deaths by Sleep Circumstances (*n* = 51): 2011–2014

	Age at Death 0–6 mo ^a	
	<i>n</i>	%
Sleep place		
Adult bed	36	71
Chair or couch	13	25
Crib or bassinet	^b	^b
Other	^b	^b
Found position		
Prone	14	27
Side	12	24
Supine	25	49
Person involved with overlay		
Mother	24	47
Father	13	25
Sibling	11	22
Other	3	6
Airway obstruction mechanism		
Neck or chest compression	36	71
Nose and mouth obstruction	11	22
Unknown or both	4	8
Adult fell asleep feeding the infant		
No or unknown	41	80
Yes	10	20
Feeding type among adults who fell asleep feeding the infant (<i>n</i> = 10) ^c		
Breast	7	70
Bottle	3	30
Person who overlaid impaired by drugs or alcohol (<i>n</i> = 40) ^d		
Yes	9	23
No, not specified, or unknown	31	78

Groups do not equal 100% because of rounding.

^a There were no deaths after 6 mo of age.

^b Per the data-use agreement with states, counts of 1 through 2 are suppressed in an effort to protect confidentiality.

^c Denominator = adults who fell asleep feeding.

^d Denominator = adult or nonsibling overlays.

The American Academy of Pediatrics (AAP) recommends that infants sleep supine in a safety-approved crib, bassinet, or portable crib with no soft objects or bedding in the sleep area.¹⁴ The AAP also recommends that infants share a room but not a sleep surface.¹⁴ Following the AAP

safe-sleep recommendations can prevent suffocation deaths.

Despite differences in case inclusion criteria, definitions, and the process of assigning cause of death and mechanism, some of our findings are consistent with earlier studies

examining infant sleep-related suffocation deaths.^{15–20} Among suffocation deaths, there was a higher proportion of younger infants.^{15–17}

Overlay deaths were more common among infants 0 to 2 months old, and wedging deaths were more common among infants 3 to 6 months old.¹⁷ Pillows, mattresses, and blankets or comforters were the most common objects obstructing infant airways.¹⁵ As in our study, most overlay deaths occurred on an adult bed or couch,^{17,18} and infants were most often overlaid by a parent or sibling.^{16,18} Although an infrequent occurrence, other studies have also reported overlay deaths when the infant's mother fell asleep breastfeeding.¹⁶ Wedging deaths most commonly occurred between a mattress or bed and wall,^{15–18} and those that occurred in a crib were related to an ill-fitting mattress or faulty crib.^{16,17,19}

Our analyses were subject to some limitations. A high level of detailed evidence about the circumstances at death was required to be categorized as suffocation with the classification system. As a result, there may have been infants included in the Case Registry during the study years who were suffocated by hazards in their sleep environments, but the death investigation or documentation lacked the evidence necessary for the case to be categorized as suffocation. Like earlier SUID studies, information about a surface sharer's drug and alcohol impairment was not documented consistently.^{21,22}

Furthermore, because this was a descriptive study of a population of infants who died, we lacked a comparison group and thus were unable to quantify risk associated with infant sleep practices (ie, there was no control group). Also, the size of the study population limited our ability to make meaningful observations about some of the smaller groups in our stratified analyses.

Despite these limitations, our data source and the resulting analyses have several strengths. Case Registry

TABLE 4 Suffocation Wedging Deaths by Sleep Circumstances (*n* = 33): 2011–2014

	<i>n</i>	%
Sleep place		
Adult bed	24	73
Crib or bassinet	4	12
Other (including chair or couch)	5	15
Sharing a sleep surface with another person		
No	17	52
Yes	15	45
Unknown	^a	^a
Objects infant was wedged between		
Mattress and wall	16	48
Mattress and bed frame	9	27
Crib mattress and other	^a	^a
Other (eg, in a stroller or between ottoman and couch)	^a	^a

^a Per the data-use agreement with states, counts of 1 through 2 are suppressed in an effort to protect confidentiality.

states committed to conducting population-based SUID surveillance and received targeted assistance and resources from the CDC to improve data quality and completeness.^{6,7}

Earlier studies have used data derived from the National Fatality Review Case Reporting System without restricting cases to those from Case Registry states and thus have had less complete data.^{23–25} The strengths of Case Registry data address the limitations of other available data sources, such as death certificates. Studies using only death-certificate data lack specifics about the sleep environment and are limited by inconsistent classification of suffocation deaths. Case Registry data include detailed information about the sleep environment, allowing for classification on the basis of strong evidence of suffocation by using standardized criteria and definitions⁸ and the differentiation of airway obstruction by mechanism. Finally, because complete and comprehensive data about the sleep environment were required to classify a case as suffocation, there were no missing and

unknown responses for any sleep-environment variables.

CONCLUSIONS

Since 1999, there has been a dramatic increase in the number of US infant deaths attributed to suffocation. These observed rates may not be fully explained by increased incidence and are at least partly attributed to changing diagnostic preferences and improved death investigations.² Regardless, unintentional injury deaths, such as those categorized as suffocation in our study, can be prevented by following infant safe-sleep practices. The safest place for infants to sleep is on their backs, on an unshared sleep surface, in a crib or bassinet in the caregivers' room, and without soft bedding (eg, blankets, pillows, and other soft objects) in their sleep area.¹⁴ Improving our understanding of the characteristics and risk factors (eg, age differences and sleep-environment characteristics) of suffocation deaths by mechanism of airway obstruction

can inform the development of more targeted strategies to prevent these injuries and deaths.

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ABBREVIATIONS

AAP:	American Academy of Pediatrics
ASSB:	accidental suffocation and strangulation in bed
CDC:	Centers for Disease Control and Prevention
SIDS:	sudden infant death syndrome
SUID:	sudden unexpected infant death

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