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Bunk versus conventional beds: a comparative assessment of fall injury risk

M Belechri, E Petridou, D Trichopoulos

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See end of article for authors' affiliations

Correspondence to: Dr E Petridou, Department of Hygiene and Epidemiology, Athens University Medical School, 75 Mikras Asias, Goudi, Athens 115–27, Greece; epetrid@med.uoa.gr

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Objective: To depict the magnitude and spectrum of childhood injuries attributable to falls from bunk beds in comparison with conventional beds and to outline sociodemographic risk factors and injury characteristics.
Study design: Case-control investigation.
Setting: Accident and emergency departments of four hospitals in Greece, namely a teaching children's hospital and a trauma hospital in Greater Athens and the two district hospitals in the Magnesia county and the Corfu island.
Patients: During the three year period 1996–98, 1881 children (0–14 years) presenting with bed fall injuries were recorded by the Emergency Department Injury Surveillance System (EDISS). Out of these, 197 children with falls from bunk beds served as cases and 1684 children with falls from conventional beds served as controls.
Results: From the analysis and a nationwide extrapolation, it was calculated that each year about 5000 children in Greece (total population 10 million) seek medical attendance at an emergency department for a bed injury, corresponding to an estimated incidence of about 3 per 1000 children years. Out of bed fall injuries, 10.5% are from bunk beds, 10.4% from cribs, 3.1% from cots, and 76.0% from other conventional beds. Falls from the bed ladder accounted for 8% of all bunk bed injuries. Boys are at higher risk for falls from beds but there is no evidence that the proportion is different depending on the type of bed used. Relatively few falls from bunk beds are recorded outside the crowded apartments of Greater Athens or among migrant children. The increased relative risk of injuries from bunk bed falls during the sleeping hours indicates the higher risk of injury after a fall from a bunk rather than a conventional bed. Injuries from bunk bed falls are generally more serious than those from conventional bed falls (overrepresentation of brain injuries, fractures, multiple injuries, and injuries requiring hospitalisation). Overall, it can be estimated that almost half of the sleep related bunk bed injuries are easily preventable.
Conclusions: Falls from bunk beds represent a non-negligible childhood injury risk. A sizeable fraction can be avoided with simple design modifications of the product, such as use of side rails in the upper bed or removal of the bed ladder when not in use.

It had been pointed out by a number of authors [1 2] that injury prevention, in contrast with prevention of most diseases, depends on the identification and eventual neutralisation of many causes, each contributing to minor increments of the overall injury risk. Many of these—individually minor but collectively substantial—contributions to injury risk have been associated with novel products and processes that were introduced to facilitate current housing, transportation, play, or entertainment needs.

Bunk beds have been introduced in response to space saving needs in crowded urban dwellings and their spread was accelerated by their apparent popularity among playful children.[3] Simple consideration of physical laws indicates that bunk beds should impose an excess injury risk in children and a number of case series have helped to document that such a risk actually exists. We have undertaken a study in Greece to assess the risk for childhood injury from bunk bed falls in this country. Moreover, we have used a control series of fall injuries from conventional beds, as the alternative to bunk bed use is not their elimination but improvement of their safety features, so that they approximate those of a conventional bed.

METHODS

During the three year period 1996–1998, 1881 injuries attributable to falls from beds among children (0–14 years) residing in the Greater Athens area, in a tourist island (Corfu) or in the Magnesia area of mainland Greece, were recorded in the Emergency Department Injury Surveillance System (EDISS) run by the Centre for Research and Prevention of Injuries among the Young (CEREPRI). According to the operational definition used in this study, all injuries attributable to falls from beds, bunk beds and cribs or cots were included. Bunk bed falls are considered only those that occurred from the upper bed or the ladder. Trauma rubrics of the European Home and Leisure Accidents Surveillance System (EHLASS) coding manual,[4] were: 23150, 23288, 23299, 23388, 1310, and 1300. Rubrics 2221, 2220, 2228 of the NOMESCO classification [5] were used for the type of bed. In every instance, rubric based retrieval was confirmed by the available free text description.

In the Greater Athens area EDISS relies on data collected at the accident and emergency departments of two hospitals, one of which is a trauma hospital and the second is one of the two teaching children's hospitals in the area. Outside Athens, the participating institutions are district hospitals with defined catchment areas: the district hospital of Kerkyra is located on a tourist island (Corfu) and the district hospital of Magnesia, in the town of Volos, in the Greek mainland.

Specially trained health visitors interviewed in person the child and his/her guardian using a pre-coded questionnaire that contains information on sociodemographic characteristics, the mechanism and the objects most directly involved in the injury (for example, home furniture and height in case of fall), type of injury and body part injured, supervision patterns, medical

evaluation of the child, and type of treatment. The collection of data was approved by the ethics committee of the participating hospitals and the study protocol by the ethics committee of the Athens Medical School. All information was recorded and coded in a computerised database.

Incidence rates for bed injuries in Greece can be estimated from this database by use of appropriate sampling fractions. The estimation of the total number of injuries in Greece was calculated by using sampling ratios of 2.2% and 28.9% for all injuries outside and in Greater Athens, respectively.[6]

Injured children were divided into groups; those injured because of a fall from a conventional bed, crib or cot, and those injured on account of a bunk bed fall. The initial analysis was performed using simple cross tabulations. The odds ratio for an injury attributable to fall from a bunk bed rather than a conventional bed was calculated through multiple logistic regression.[7] The SAS statistical software was used. It should be realised that this analysis relies on proportional distributions because no estimates are available about conventional bed and bunk bed availability in the population of Greece.

RESULTS

A total of 1881 injuries attributable to falls from beds were recorded in EDISS over the three year period 1996–98, corresponding to an incidence rate of 3 per 1000 children years and an estimated annual number of about 5000 such injuries among children throughout Greece.

Table 1 shows the distribution of injuries attributable to bed falls recorded in EDISS during a three year period by demographic, accident and injury characteristic, as well as type of bed. The data in this table do not allow estimations of the relative risk for a bed fall injury by type of bed (conventional or bunk bed) because the frequency of these

Table 1 Distribution of the 1881 childhood (0–14 years) injuries attributable to falls from beds recorded in EDISS during the three year period 1996–1998 by demographic, accident, and injury descriptive variables and type of bed (bunk bed or conventional)

Variable	Bunk bed number (%)	Conventional bed number (%)	p Value
Age (y)			0.001
0–4	94 (47.7)	1350 (80.2)	
5–9	80 (40.7)	255 (15.1)	
10+	23 (11.6)	79 (4.7)	
Gender			0.82
Male	109 (55.3)	946 (56.2)	
Female	88 (44.7)	738 (43.8)	
Place of residence			0.14
Greater Athens	182 (92.4)	1498 (89.0)	
Magnesia-Corfu	15 (7.6)	186 (11.0)	
Nationality			0.01
Greek	195 (99.0)	1606 (95.4)	
Migrant	2 (1.0)	78 (4.6)	
Time of accident			0.001
0600–0959	13 (6.6)	147 (8.7)	
1000–1359	28 (14.2)	399 (23.7)	
1400–1759	64 (32.5)	458 (27.2)	
1800–2159	69 (35.0)	579 (34.4)	
2200–0559	23 (11.7)	101 (6.0)	
Day of accident			0.45
Weekday	68 (34.5)	537 (31.9)	
Weekend	129 (65.5)	1147 (68.1)	
Season of accident			0.05
Winter	50 (25.4)	343 (20.4)	
Spring	49 (24.9)	378 (22.4)	
Summer	34 (17.2)	431 (25.6)	
Autumn	64 (32.5)	532 (31.6)	
Activity			0.09
Leisure	160 (81.2)	1442 (85.6)	
Sleep	37 (18.8)	242 (14.4)	
Injured body part			0.001
Brain	28 (14.2)	96 (5.7)	
Skull	46 (23.3)	682 (40.5)	
Face	53 (26.9)	491 (29.2)	
Trunk	22 (11.2)	115 (6.8)	
Upper limbs	33 (16.8)	195 (11.6)	
Lower limbs	15 (7.6)	105 (6.2)	
Type of injury			0.001
Contusion, abrasion	56 (28.4)	445 (26.4)	
Open wound	37 (18.8)	496 (29.4)	
Fracture	39 (19.8)	220 (13.1)	
Concussion	29 (14.7)	91 (5.4)	
Other	8 (4.1)	69 (4.1)	
No injury diagnosed	28 (14.2)	363 (21.6)	
Number of injuries			0.001
Single	162 (82.2)	1562 (92.8)	
Multiple	35 (17.8)	122 (7.2)	
Outcome			0.001
Non-hospitalised	164 (83.3)	1586 (94.2)	
Hospitalised	33 (16.7)	98 (5.8)	
Total	197 (100.0)	1684 (100.0)	

Table 2 Multiple logistic regression derived odd ratios (ORs) and 95% confidence intervals (95% CI) for a bunk bed fall rather than a conventional bed fall injury by a series of demographic and accident descriptive variables

Variable	Category or increment	OR	95% CI	p Value
Age	0–4 years	baseline		
	5–9	4.89	3.48 to 6.88	0.001
	10+	4.21	2.47 to 7.19	0.001
Gender	Male	baseline		
	Female	0.98	0.72 to 1.35	0.92
Place of residence	Greater Athens	1.65	0.93 to 2.93	0.08
	Magnesia-Corfu	baseline		
Nationality	Other	0.19	0.05 to 0.80	0.02
	Greek	baseline		
Time of accident	0600–0959	1.17	0.57 to 2.43	0.66
	1000–1359	baseline		
	1400–1759	2.10	1.30 to 3.42	0.002
	1800–2159	1.57	0.98 to 2.54	0.06
	2200–0559	2.51	1.30 to 4.88	0.006
Day of accident	Weekday	0.96	0.69 to 1.35	0.85
	Weekend	baseline		
Season of accident	Winter	1.89	1.16 to 3.09	0.01
	Spring	1.50	0.93 to 2.44	0.09
	Summer	baseline		
	Autumn	1.52	0.96 to 2.42	0.07
Activity	Leisure	baseline		
	Sleep	1.49	0.96 to 2.34	0.07
Number of injuries	Single	baseline		
	Multiple	3.03	1.95 to 4.72	0.0001
Additional, alternatively introduced variables				
Injured body part	brain	2.35	1.30 to 4.27	0.005
	skull	0.65	0.41 to 1.05	0.08
	face	0.82	0.52 to 1.32	0.42
	trunk	1.43	0.80 to 2.58	0.23
	limbs	baseline		
Type of injury	contusion, abrasion	1.67	1.06 to 2.64	0.02
	open wound	baseline		
	fracture	2.00	1.21 to 3.33	0.006
	concussion	4.33	2.39 to 7.88	0.0001
	other	1.36	0.59 to 3.18	0.47
	no injury diagnosed	1.39	0.81 to 2.40	0.23
Outcome	non-hospitalised	baseline		
	hospitalised	2.87	1.77 to 4.65	0.0001

two types of beds in the population at large and by specific demographic characteristics is not known. Thus, the information in this table serves only descriptive purposes. There were 197 fall injuries (10.5%) from bunk beds, 196 injuries from cribs (10.4%), 58 from cots (3.1%), and 1430 (76 %) from other conventional beds. Falls from the bed ladder accounted for 8% of all bunk bed injuries.

Falls from conventional beds are concentrated among children less than 5 years old and sharply decline with advancing age. The decline with advancing age is also evident among falls from bunk beds but it is much milder, possibly because it represents the composite of a declining trend (associated with maturation and developmental advancement of the child) and an increasing trend in the frequency of bunk bed use with increasing age. Boys are at higher risk for falls from beds but there is no evidence that the proportion is different depending on the type of bed used. Fewer falls from bunk beds are recorded outside the Greater Athens area and among children of migrant parents, but these patterns are likely to represent the higher use of bunk beds by Greeks residing in the crowded apartments of the Greater Athens area, rather than among the other indicated population groups. With respect to the actual time of accident, the distribution of injuries is different depending on the type of bed; the difference seems to be driven by an overrepresentation of falls from bunk beds during the afternoon and night sleeping hours (2 pm to 6 pm and 10 pm to 6 am).

It seems logical that the excess of injuries during the sleeping hours from bunk bed falls reflects the higher inherent risk for injuries from these falls in comparison with falls from conventional beds.

A deficit of bunk bed injuries during the summer may indicate that summer vacations are more institutionalised among households that use bunk beds. There is also evidence that the incidence density of falls is slightly higher during the two day period weekend, than during the five day period of working days, and the excess weekend incidence seems to be related to leisure rather than sleep time events (data not shown). Adults seem to be absent less frequently in the case of a fall from a bunk bed rather in that from a conventional bed (14% versus 38%).

Table 3 Distribution of the 1881 childhood (0–14 years) injuries attributable to bed falls recorded in EDISS for the three year period 1996–1998 by age, activity, and type of bed

	Age					
	0–4		5–9		10+	
	Bunk bed number (%)	Conventional bed number (%)	Bunk bed number (%)	Conventional bed number (%)	Bunk bed number (%)	Conventional bed number (%)
Activity						
leisure	83 (88.3)	1142 (84.6)	66 (82.5)	230 (90.2)	10 (47.8)	70 (88.6)
sleep	11 (11.7)	208 (15.4)	14 (17.5)	25 (9.8)	12 (52.2)	9 (11.4)
Total	94 (100.0)	1350 (100.0)	80 (100.0)	255 (100.0)	23 (100.0)	79 (100.0)
Odds ratio		0.72		1.95		8.48
p Values		0.33		0.06		0.0001

*Odds ratio for a bunk bed injury attributable to a fall during sleep rather than during leisure time.

Injuries from bunk bed falls are generally more serious than those from conventional bed falls. This is shown in the overrepresentation of brain injuries, fractures, multiple injuries, and injuries requiring hospitalisation among those with falls from bunk beds rather than among those with falls from conventional beds.

Table 2 shows multiple logistic regression derived, mutually adjusted odds ratios for an injury with a certain characteristic (for example, age, gender, day, sleeping) to be bunk bed, rather than conventional bed, related. With respect to demographic characteristics like age, gender, place of residence and ethnic group the adjusted findings reflect the patterns of the unadjusted ones presented in table 1. The deficit of summer injuries from bunk bed falls is also evident in the adjusted data as is the apparent excess of sleep related fall injuries from bunk beds (explained, as previously indicated, from a deficit of injury causing falls from conventional beds). The data also confirm that serious and multiple injuries are attributable to bunk bed falls.

Table 3 shows that for children aged 5–9 and 10 and over, bunk bed falls are considerably more likely to cause an injury that requires hospital contact in comparison with falls from conventional beds. The odds ratio (relative risk) of an injury causing fall during sleep rather than leisure time, comparing bunk beds with conventional beds, is close to one for 0–4 years old, but becomes almost two in the 5–9 years age group and almost ninefold among those older than 10 years ($p<0.001$). The explanation of this pattern is that bunk bed falls are much more likely to cause injury and require medical attention than falls from conventional beds. Indeed, on the basis of data in this table it can be estimated that almost half of the sleep related bunk bed injuries could have been avoided if simple precautions were implemented. Thus, among children aged 5–9, half of the sleep related bunk bed injuries (that is seven of them) and among children aged 10 and over most of the bunk bed injuries (that is 10 to 11 of them) could have been prevented with the use of specially designed rails around the upper bed. Under the assumption that no intervention takes place it can be estimated that the total preventable fraction is 17 to 18 of 37 or about 50%.

DISCUSSION

This study shows that 3 of 1000 children years are injured after a bed fall in Greece. About 10% of these injuries are caused after a fall from a bunk bed and these injuries are far more serious than those after a fall from a conventional bed. The progressive urbanisation of Greece indicates that the use of bunk beds and the frequency of bunk bed falls are likely to increase in the immediate future. Bunk beds should be avoided for children younger than 5 years and simple safety precautions could reduce the frequency of bunk bed injuries serious enough to require hospital contact.

Key points

- Falls from bunk bed represent a non-negligible childhood injury risk (in Greece about 5000 children seek medical attendance at an emergency department for a bed injury, each year, corresponding to an estimated incidence of about 3 per 1000 children years).
- Bunk beds are considered a solution to the lack of space in the crowded urban apartments. Yet, availability of a bunk bed increases the risk of a fall injury, that is of relatively higher severity compared with those caused from conventional beds
- It can be estimated that almost half of the sleep related bunk bed injuries are easily preventable with simple design modifications of the product, such as use of side rails in the upper bed or removal of the bed ladder when not in use.
- Effective parental supervision during times when children play inside home would contribute to the reduction of the risk associated with the availability of these products

Previous studies[3 8–10] have pointed out the inherent risks of bunk bed falls and this investigation documents that injuries from bunk bed falls are considerably more serious than those after falls from conventional beds. The size of the problem of bunk bed injuries seems to be of about the same order of magnitude in countries such as the USA and Australia,[9] although data concerning the frequency of utilisation of bunk beds and time activity patterns in various populations are too limited to allow calculation of proper incidence figures per person time at risk.

A limitation of this investigation, which is shared by earlier ones, is that, denominator figures were not available, a fact that highlights the importance of collecting population data on exposures in the course of injury surveillance, either routinely or on an ad hoc basis once a putative risk or hazard has been identified. The large study size and the use of a control group comprising injuries from conventional beds does not solve this problem, but permits the firm documentation of the increased severity of injuries from bunk bed falls and points to factors that seem to increase the risk of a bunk bed injury.

Injury resulting from a bunk bed fall is a function of the risk of fall and the risk of injury following the fall. Reducing the risk of fall should focus on both person characteristics (for example, limitation of bunk bed use to older children) and microenvironmental characteristics (for example, use of protective rails and removal of the ladder during the day). On the other hand, the consequences of fall could probably be diminished by alteration of the microenvironment characteristics, including carpeting of the floor [11–13] and avoidance of proximate edges. Several European Union countries have already introduced safety regulations serving these objectives.[14] Lastly, increased parental awareness on provision

of effective supervision during times when children play inside home would contribute to the reduction of the risk associated with the availability of these products.

Reduction of the burden of injuries is an uphill battle and every small victory should be considered an important one. The recognition that 3 of 1000 children are injured every year as a result of a bed fall, as well as the documentation that these injuries are considerably more serious when the fall is from a bunk rather than a conventional one, have contributed to the formulation of indicated strategies towards a reduction of childhood injuries as a consequence of bed falls.

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Authors' affiliations

M Belechri, E Petridou, D Trichopoulos, Department of Hygiene and Epidemiology, Athens University Medical School, Athens, Greece
E Petridou, D Trichopoulos, Department of Epidemiology, Harvard School of Public Health, Boston, USA

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