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Original Report

Defective Assistive Device Involvement in Older Adult Emergency Department Visits

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Abstract

Background and Objectives: Many older adults adopt equipment to address physical limitations and reduce dependence on others to complete basic activities of daily living. Although a few prior studies have considered injuries associated with assistive devices for older adults, those studies focused on older adults' health and functional risks for injury. There is limited analysis of older adult injuries involving defective or malfunctioning assistive devices.

Research Design and Methods: Data from this study are from the National Electronic Surveillance System All Injury Program which collected data on consumer product-related injuries from a probability sample of 66 hospital Emergency Departments across the United States. Data from 30 776 older adult Emergency Department (ED) injury narratives from 2016 to 2020 were coded according to the assistive device involved and whether malfunctioning led to the injury. The study team manually examined all narratives in which the assistive device was coded to have malfunctioned.

Results: A total of 10 974 older adult ED cases were treated for 12 488 injuries involving a defective device. Injuries included 4 212 head and neck injuries (eg, concussion), 4 317 trunk injuries (eg, hip fractures), and 3 959 arm or leg injuries (eg, leg fracture). Of these patients, 4 586 were admitted to a hospital ward for further evaluation and treatment. Seventy percent of these patients were injured while using a walker; in contrast, wheelchairs were implicated in only 4% of the above cases. Design flaws were identified in 8 158 cases and part breakage/decoupling incidents in 2 816 cases.

Discussion and Implications: Our findings provide evidence that assistive devices are actively involved in older adult injuries. Further research is needed to reduce injuries associated with assistive devices by educating patients and their careproviders about device use and assembly and developing effective methods for informing manufacturers about malfunctioning devices.

Translational Significance: There is limited analysis of older adult injuries involving malfunctioning assistive devices. Findings from nationally representative narrative data extracted from medical records revealed that nearly 1 out of 100 older adult Emergency Department visits from 2016 to 2020 were associated with the use of an assistive device including canes, commodes, safety handles, shower chairs, walkers, and wheelchairs. A detailed review of the narrative data provided clear evidence that product malfunctioning is associated with older adults' injuries. Beyond health professionals' educational interventions aimed at proper device selection and use, these findings suggest that updated standards and quality checks are needed for these devices.

Keywords: Injuries, Safety, Malfunctioning devices, Product design, Responsible production

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Two-thirds of older adults have difficulty completing 1 or more basic daily activities, including ambulating inside and outside, getting out of bed, eating, bathing, toileting, and dressing (1). Nearly a quarter address these difficulties by adopting personal assistance and environmental modifications, such as grab bars, or assistive devices, such as canes and walkers (2). According to Verbrugge's and Jette's conceptual framework of disablement (3), the effects of experiencing difficulties with basic activities of daily living can be addressed in several ways, including reducing environmental barriers, engaging personal care, and acquiring assistive devices. Several studies have shown that the adoption of assistive devices reduces dependence on others to successfully complete daily activities (1,4–6). In addition, these devices are also intended to reduce fall and injury risk (7,8). Yet, falls and injuries continue to occur among older adults who adopt assistive devices (9–11). Although muscle weakness, gait and balance deficits, and a history of falls are associated with falls among older adults who adopt assistive devices (8), there is emerging evidence that some of these injuries may be due to faulty equipment (9,10). However, very little is known about the context of injuries associated with assistive devices, particularly the involvement of malfunctioning products in these injuries.

The Consumer Product Safety Commission, the U.S. federal regulatory agency in charge of reducing consumer product injury risk, reported that an estimated 14.6 million older adults visited U.S. Emergency Departments (ED) due to injuries associated with, but not necessarily caused by, consumer products from 2016 to 2020 (12). Of these, nearly two-thirds of visits were due to falls (12), providing further evidence for the need to assess the context of injuries associated with assistive devices that are meant to increase older adults' independence and reduce the risk of injuries. To date, research on assistive device use has largely addressed their potential to reduce dependence on others to complete basic daily activities (1,4). The few studies that have looked at injuries associated with their use have focused on the risk factors for injury, such as a history of falls (13), rather than the overarching context. There has been limited analysis of the involvement of *defective* assistive devices in older adult incidents that lead to injury.

Past studies (14–16) have successfully used hospital narratives to draw valuable insight into the incidence rates of specific injury types in select, vulnerable populations. One study (14) used hospital narratives from the Queensland Injury Surveillance Unit to measure the extent of consumer product involvement in pediatric injuries. Another study used hospital ED narratives, from the National Electronic Injury Surveillance System All Injury Program (NEISS-AIP) database, to quantify scald burn incidence among children under 3 years of age (15) and injuries associated with housing elements for children under 18 years of age (16). These studies provide evidence for the value of analyzing hospital narratives to assess the safety of products used by other vulnerable constituencies, such as older adult assistive devices.

Therefore, this descriptive study aims to present findings from text analysis of NEISS-AIP hospital ED narratives. The findings will provide a better understanding of the roles and circumstances under which the use of assistive devices, specifically, canes, commodes, safety handles/bars/rails, shower chairs, walkers, and wheelchairs are linked to older adult injuries requiring ED visits.

Method

Data Overview

The NEISS-AIP collects data on consumer product-related injuries from a probability sample of 66 hospital EDs across the United States (17). NEISS-AIP data include a clinical narrative describing the incident, as well as details on patient demographics, diagnoses, consumer product involved (via consumer products and activity codes), and whether the visit resulted in discharge to home from the ED or transfer to a hospital ward. Additionally, sampling weights (ie, the number of people in the U.S. population that each case represents) are assigned to every case, allowing for the calculation of nationally representative estimates (17).

A subset of the NEISS-AIP data (180 191 cases), dated between 2016 and 2020, was obtained by using the NEISS-AIP online query builder, which lets researchers extract injury cases using customized search criteria (see Figure 1 for a complete methodology diagram). Study personnel used the following inclusion criteria for extracting the data: (a) the patient was medically evaluated in the ED, (b) the patient was aged 65 years or older, and (c) at least 1 of the following 6 consumer product and activity codes were involved in the incident: 611—Bathtubs or Showers, 649—Toilets, 1807—Floors or Flooring Materials, 1842—Stairs or Steps, 4074—Chairs, and 4076—Beds or Bedframes. Given that NEISS-AIP no longer uses product and activity codes specific to assistive devices, we identified all codes associated with areas of the home where assistive device products are used. Note that product and activity codes are often representative of a group

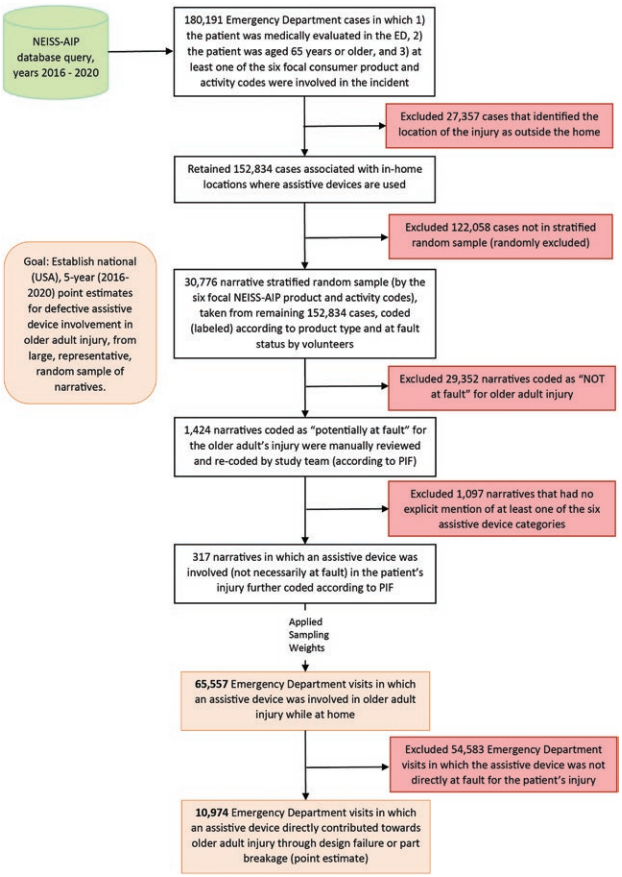

Figure 1. Data coding, filtering, and analysis process.

of products, structures, or activities perceived to belong to the same environment, rather than a specific item. For example, according to NEISS-AIP guidelines, bath grab bars and other bath products, such as bath caddies, are all coded under 611—Bathtubs or Showers.

We excluded all cases where the location of the injury was outside the home (27 357 cases). The presence of external environmental factors, such as uneven or cracked surfaces, made it impossible to determine if the assistive device or an environmental factor was associated with the mentioned injury. This exclusion criterion resulted in the retention of 152 834 cases out of the initial 180 191 sample pool.

From these 152 834 cases, 30 776 were selected, through a stratified (by the 6 focal product and activity codes) random sample, to have their clinical narratives manually coded.

Developing 5-Year (2016–2020) Point Estimates for Defective Assistive Device Involvement in Older Adult Injury, From a Large, Representative, Random Sample of Narratives

The 30 776 narratives were manually coded to (a) establish national point estimates for injuries attributable to defective older adult assistive devices and (b) characterize the manner in which the devices contributed towards the injury. The sample narratives were coded (labeled) by 205 undergraduate student-volunteers (junior raters) from a Triple Crown accredited university in Thailand and a top 20 public land-grant university in the United States. Volunteers were asked to code narratives across 2 dimensions: product type and at-fault status. Every volunteer was provided with an electronic copy of a labeling protocol document (https://data.mendeley.com/datasets/7nkw7n4y34/1) containing instructions, key terminology, visual examples, detailed descriptions of each label, and sample cases on how to appropriately code the narratives. Prior to actual coding, coders' understanding of the protocol was assessed through a qualification exam, in multiple-choice format, with 25 pre-coded questions by the senior coder (lead author). Volunteers who scored under 80% were deemed to be ineligible for data coding. 225 volunteers were invited to complete the qualification examination, and 208 of these volunteers passed the examination with a qualifying score of 80% or higher. The average qualifying examination score of these 208 qualified coders was 88.49%. 205 of the 208 qualified volunteers elected to proceed to the large-scale coding exercise.

Each question—in both the qualification exam, and the subsequent coding task—required the volunteer to select from 7 product type options (*cane*, *commode, safety handle/rail/bar*, *shower chair*, *walker*, *wheelchair, or other*) and 3 at-fault statuses (*potentially at fault*, *not at fault*, or *no consumer product mentioned*). The definitions of both primary coding dimensions (product type and at-fault status) have been included in the "Definition of Primary Coding Dimensions" section of the Supplementary Material.

The volunteers identified a total of 1 424 narratives in which an assistive device or other consumer product was potentially at fault for the patient's injury. Of these, 1 097 narratives had no explicit mention of at least 1 of the 6 assistive device categories (canes, commodes, safety handles/bars/rails, shower chairs, walkers, or wheelchairs) and were excluded from the data. The remaining 317 narratives described injury events associated with the 6 focal assistive device categories.

The 2 senior coders on the study team then verified and further classified the 317 potentially at-fault designations by using a more nuanced assessment of how the product contributed to the injury: Product Impact Factor (PIF) (14). PIF's 8 assessment categories are shown in Supplementary Table 1A. Narratives coded under "*PIF category 4: Consumer product with malfunction or faulty parts*" (Supplementary Table 1A), indicating that there is a clear, identifiable assistive device failure mechanism that directly contributed to the injury, were further coded by the study team according to the specific failure mechanism: *part breakage/decoupling* or *design failure* (definitions can be found in the "Definition of Primary Coding Dimensions" section of the Supplementary Material). Intercoder reliability was considered by the senior coders who further classified the shortlisted "at fault" designations via the Product Impact Factor framework. Inter-rater reliability was 0.62, indicating substantial agreement as per Landis and Koch (18).

Once coded, sampling weights were applied to all 317 narratives to obtain ED visit national estimates for cases in which assistive devices were involved (not necessarily at fault) and cases in which the device directly contributed to the patient's injury (PIF Category 4).

Results

After applying the sampling weights to the shortlisted narratives, we found that approximately 65 557 narratives, representing nearly 1 out of 100, of older adult American ED visits over the 5-year study period (2016–2020), were associated with the use of an assistive device. Of these 65 557 ED visits, 10 974 (17%) involved a malfunctioning assistive device with a clear, identifiable failure mechanism (PIF Category 4). These 10 974 cases resulted in a total of 12 488 injuries (NEISS-AIP provides up to 3 injury diagnoses per case).

Table 1 shows malfunctioning assistive device national estimates for internal, musculoskeletal, and external injury types by body part affected. We identified a total of 3 459 internal injuries (eg, "*70yom was walking with a cane, cane slipped and fell hit lower leg against a cabinet. Dx:* hematoma"), of which 2 626 (76%) were reported to have occurred in the head or neck area. These 2 626 internal head or neck injuries were predominantly attributed to malfunctioning walkers (1 792 cases; 68%) and safety handles/bars/rails (387 cases; 15%). Regarding musculoskeletal injuries (eg, "*98yof, her walker caught on the carpet and fell onto the floor at home tonight. Dx:* right hip fracture"), we found a total of 5 990 cases, largely split between the trunk (2 790 cases; 47%) and arm or leg (2 880 cases; 48%) body areas (Table 1). Similar to head or neck injuries, the majority of trunk and arm or leg musculoskeletal injuries were attributed to malfunctioning walkers, with 1 821 (65%) and 1 811 (63%) cases, respectively. Canes were also found to have accounted for 18% (501 cases) of trunk musculoskeletal injuries.

We identified a total of 3 039 external injuries (eg, "*95yom was getting up from commode when he reached for grab bar and bar fell off wall. fell. Dx:* scalp laceration"), relatively evenly distributed between the head or neck (1 266 cases; 42%), trunk (972 cases, 32%), and arm or leg (801 cases, 26%) areas (Table 1). In the case of head, neck, and trunk external injuries, malfunctioning walkers accounted for the overwhelming majority of incidents for both body areas, with

Table 1. Malfunctioning Product National Estimates[a] by Body Part Affected and Injury Type Diagnosis (2016–2020)

Body part affected	Diagnosis	Cane	Commode	Safety handle/bar/rail	Shower chair	Walker	Wheelchair	Total
Head or neck	Internal injury	47 (2%)	147 (6%)	386 (15%)	254 (10%)	1792 (68%)	0	2 626
	Musculoskeletal injury	0	0	21 (7%)	0	298 (93%)	0	320
	External injury	0	0	114 (9%)	99 (8%)	1054 (83%)	0	1 266
	Total	47 (1%)	147 (3%)	521 (12%)	353 (8%)	3 144 (75%)	0	4 212
Trunk	Internal injury	0	0	0	156 (28%)	400 (72%)	0	555
	Musculoskeletal injury	501 (18%)	122 (4%)	120 (4%)	188 (7%)	1821 (65%)	38 (1%)	2 790
	External injury	0	20 (2%)	114 (12%)	0	639 (66%)	200 (21%)	972
	Total	501 (12%)	141 (3%)	234 (5%)	344 (8%)	2 860 (66%)	238 (6%)	4 317
Arm or leg	Internal injury	177 (64%)	0	0	0	101 (36%)	0	278
	Musculoskeletal injury	0	291 (10%)	499 (17%)	128 (4%)	1811 (63%)	151 (5%)	2 880
	External injury	0	243 (30%)	0	81 (10%)	478 (60%)	0	801
	Total	177 (4%)	534 (13%)	499 (13%)	208 (5%)	2 390 (60%)	151 (4%)	3959
Grand total		725 (6%)	822 (7%)	1 254 (10%)	905 (7%)	8 394 (67%)	389 (3%)	12 488

Note: NEISS-AIP = National Electronic Injury Surveillance System All Injury Program.
[a]Weighted counts include both primary and secondary NEISS-AIP injury type and body part diagnoses.

1 054 (83%) and 639 (66%) cases, respectively. Arm or leg external injury distribution was split between malfunctioning walkers (478 cases; 60%) and commodes (243 cases; 30%).

Table 2 shows that among patients admitted to a hospital emergency room for an equipment-related injury, the average age was 81. Head or neck injuries associated with the use of a cane or commode were experienced by women but not men. Trunk, arm, or leg injuries associated with safety handles/bars/or rails and walkers were predominately experienced by females.

Table 3 shows malfunctioning assistive device national estimates for device failure mechanism (design failure or part breakage/decoupling) and patient disposition (transferred to a hospital ward or same-day treatment and release). We found that 8 157 (74%) incidents were due to product design failure and 2 816 (26%) due to part breakage/decoupling (totaling 10 974 cases). Out of these 10 974 cases involving malfunctioning assistive devices, 4 586 (42%) resulted in older adults transferring to a hospital ward. A total of 95% of cases (4 374) requiring transfer to the hospital ward were due to product design failure. In 89% of design failure incidents leading to hospital ward admission (3 898 cases) were attributed to walkers (Table 2). On the other hand, part breakage/decoupling rarely led to hospital ward admission (<5%), with safety handles/bars/rails accounting for the majority of cases for both hospital ward admission (111 cases; 52%) and same-day patient treatment and release (1 096 cases; 42%).

Table 3 shows the demographic characteristics (age and gender) by assistive device and body part affected.

Supplementary Tables 2A and B display the specific NEISS-AIP injury and body part codes included in this study's 3 injury types (internal, musculoskeletal, and external) and body part groups (head or neck, trunk, or arm or leg).

Discussion

Compared to prior studies that examined patient characteristics that increase the risk for falls (13), this study assessed the contribution of equipment design failure and breakage to injuries among older adults who use assistive devices to complete basic daily activities including getting around inside, bathing, and toileting. According to nationally representative NEISS-AIP data, in the 5-year period between 2016 and 2020, approximately 42% of older adult ED visits for in-home injuries are associated with (at least) 1 of the current study's 6 selected assistive devices and subsequently resulted in the patient being transferred to a hospital ward. Using the descriptive narratives that accompany the NEISS-AIP coded data, this study found that the 6 selected assistive device types were associated with injuries leading to hospital ward admission via product malfunctions.

Notably, we found design issues to be especially prevalent in walkers, canes, and commodes. In contrast, part breakage/decoupling issues were prevalent in safety handles/bars/rails, walkers, and shower chairs. Findings specific to particular device categories are discussed in the "Detailed Discussion of Findings" section of the Supplementary Materials.

Overall, malfunctioning assistive devices were associated with 10 974 older adult injuries between 2016 and 2020,

Table 2. Malfunctioning Product National Estimates by Body Part Affected and Demographic (2016–2020)

Body part affected		Cane	Commode	Safety handle/bar/rail	Shower chair	Walker	Wheelchair	Grand mean
Head or neck								
	Mean age (*SD*)	75 (4.24)	77 (8.48)	83.6 (7.80)	73.5 (8.42)	84.1 (9.13)	N/A	81.4 (8.98)
	Women (%)	100%	100%	42.9%	50%	50%	N/A	55.1%
	Total	47 (1%)	147 (3%)	521 (12%)	353 (8%)	3 144 (75%)	0	4 212
Trunk								
	Mean age (*SD*)	85.5 (2.12)	81 (10.0)	82.3 (6.55)	76.3 (7.63)	82.9 (10.56)	80 (0)	81.9 (8.77)
	Women (%)	0%	66.7%	100%	66.7%	73.3%	50%	69%
	Total	501 (12%)	141 (3%)	234 (5%)	344 (8%)	2 860 (66%)	238 (6%)	4 317
Arm or leg								
	Mean age (*SD*)	70 (0)	82.7 (10.78)	81.3 (13.05)	77.7 (13.57)	81.8 (8.55)	70.5 (0.70)	80.4 (9.90)
	Women (%)	0%	57.1%	75%	66.7%	76.9%	100%	70%
	Total	177 (4%)	534 (13%)	499 (13%)	208 (5%)	2 390 (60%)	151 (4%)	3 959

Table 3. Malfunctioning Product National Estimates by Failure Mechanism and Disposition (2016–2020)

Failure mechanism	Disposition	Cane	Commode	Safety handle/ bar/rail	Shower chair	Walker	Wheelchair	Total
Design (slipping, tipping, handling)	Transferred to hospital ward	214 (5%)	97 (2%)	0	0	3 898 (89%)	165 (4%)	4 374
	Treated and released (same day)	510 (13%)	508 (13%)	26 (0.66%)	283 (7%)	2 233 (59%)	224 (6%)	3 784
	Total	724 (9%)	605 (7%)	25 (0.31%)	283 (3%)	6 131 (75%)	389 (5%)	8 157
Part breakage or decoupling	Transferred to hospital ward	0	0	111 (52%)	81 (38%)	20 (9%)	0	212
	Treated and released (same day)	0	290 (11%)	1 095 (42%)	287 (11%)	932 (36%)	0	2 604
	Total	0	290 (10%)	1 207 (43%)	367 (13%)	952 (34%)	0	2 816
Grand total		724 (7%)	895 (8%)	1 232 (11%)	650 (6%)	7 083 (65%)	389 (4%)	10 974

nearly half of which resulted in hospital admission after evaluation of the patient in the ED. The findings provide robust evidence that defective device use leading to injury is prevalent among older adults. Beyond health professionals' educational interventions aimed at proper device selection and use, updated standards and quality checks must be put in place for these devices. Moreover, further research is needed to continue improving their design, as products designed to prevent and accommodate injury should be safe. This is of particular concern when their user base is vulnerable to serious injury and may be fully reliant on them to complete daily self-care and mobility tasks.

Limitations

There are several limitations to this study. The extracted NEISS-AIP data for the time period of 2016–2020 contain over 300 000 recorded cases and over 1 000 product and activity codes. This study focused on a subset of 6 NEISS-AIP product and activity codes, from which 30 776 records were randomly sampled (stratified by product code). Thus, additional injury mechanisms and contexts may be present in cases associated with NEISS-AIP product and activity codes not selected in this study. Additionally, after 2010, NEISS-AIP no longer actively collects injury information regarding walkers, wheelchairs, canes, and crutches through separate product and activity codes 1706 and 1707. To address the absence of this information, the free-text narratives had to be manually examined and coded to abstract information regarding assistive device involvement for these product types. Although the NEISS-AIP manual provides no information explaining why these codes were not included in recent rounds of NEISS-AIP data, the FDA may have asserted its mandate over these devices as walkers, wheelchairs, and canes are FDA-regulated (Class I) devices.

Conclusion

We analyzed the role and involvement of 6 assistive device types in older adult ED visits from 2016 to 2020 in the United States, using NEISS-AIP data. Our findings indicate that assistive devices are associated with injuries. This suggests that significant research is needed to continue evaluating and addressing needed changes in the training of device use for patients and their care givers and in the design and safety of these devices.

Supplementary Material

Supplementary data are available at *Innovation in Aging* online.

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Conflict of Interest

None.

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