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Outcomes of Safe Patient Handling and Mobilization Programs: A Meta-Analysis

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Abstract

Objective: We performed a systematic meta-analysis of safe patient handling and mobilization (SPHM) program evaluations.

Methods: Systematic literature review identified published SPHM program evaluations. Injury Rate Ratios (IRR), pre- to post-intervention, were used to estimate intervention effects and to examine the influence of patient care level, program components, and follow-up time using meta-regression.

Results: 27 articles reported evaluations from 44 sites. Combined effect estimate for all SPHM programs was 0.44 (95% CI 0.36, 0.54), reflecting substantial injury reductions after program implementation. While specific program components were not associated with greater effectiveness, longer follow-up duration was associated with greater injury rate reduction ($p=0.01$) and intervention effects varied by level of care ($p=0.01$), with the greatest effect in intensive care unit interventions (IRR 0.14; 95% CI 0.07, 0.30).

Conclusions: SPHM programs appear to be highly effective in reducing injuries. More research is needed to identify the most effective interventions for different patient care levels.

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Keywords

healthcare; safety; hospital; safe patient handling

Introduction

The Healthcare and Social Assistance (HCSA) industrial sector employs approximately 11% of the United States work force.¹ According to 2014 Bureau of Labor Statistics data, rates of work-related illness and injury for healthcare and social assistance sector workers were more than double the average rate for all United States industries (8.1 versus 3.4 recordable cases per 100 full time workers per year, respectively).² Among the occupational factors presenting injury risks for healthcare workers, patient handling and mobilization activities are of particular concern. Lifting demands for patient care workers frequently exceed the 35 pound safe lifting limit recommended for patient handling activities derived from the National Institute of Occupational Safety and Health (NIOSH) Lifting Equation.³

Variability in patient care settings and the range of patient handling tasks present challenges in developing, implementing, and regulating safe patient handling programs. However, given the high rates of work-related musculoskeletal disorders among healthcare workers, the American Nurses Association has previously advocated for the elimination of manual patient handling.⁴ Despite such recommendations, laws requiring safe patient handling and mobilization programs in healthcare facilities exist in only 11 of 50 states. No federal legislation has been passed mandating safe patient handling programs, despite research supporting the use of multi-component ergonomic interventions to address physical workplace hazards.^{5,6} In addition, the 2012 Joint Commission publication *Improving Patient and Worker Safety: Opportunities for Synergy, Collaboration, and Innovation* also specifically notes the existence of a substantial body of literature suggesting that manual patient handling presents an injury risk for both healthcare workers and patients.⁷

In this study, a systematic comparison of safe patient handling program effectiveness was performed in order to provide answers to the following questions: (1) Do safe patient handling and mobilization programs reduce worker injuries? (2) Are certain intervention components or site characteristics associated with better program outcomes? Our hypothesis was that safe patient handling and mobilization programs would substantially reduce patient care worker injury rates and that program efficacy would be related to program elements that target manual lift elimination.

Materials and Methods

Search Criteria:

Published studies reporting safe patient handling and mobilization (SPHM) program evaluations were identified by searching for studies indexed in Pubmed, Embase, Cochrane Database of Systematic Reviews, and Web of Science using the terms [safe patient handling] and [healthcare worker injury prevention]. Pubmed search details were the following: “safe patient handling”[All Fields] OR (“health personnel”[MeSH Terms] OR (“health”[All

Fields] AND “personnel”[All Fields]) OR “health personnel”[All Fields] OR (“healthcare” [All Fields] AND “worker”[All Fields]) OR “healthcare worker”[All Fields]) AND (“Inj Prev”[Journal] OR (“injury”[All Fields] AND “prevention”[All Fields]) OR “injury prevention”[All Fields])). Identified titles were reviewed first by title and then at the abstract level to determine if a paper met the eligibility criteria. Inclusion criteria for this review were as follows: published in English, evaluation study of a safe patient handling program implemented at the unit, facility, or health system level; study focused on direct patient care workers; work-related injury and workforce exposure data (worked hours, bed-years, or patient-days) available for intervention and comparison periods; and description provided of the elements of the safe patient handling program implementation. Excluded studies were those that evaluated risk factors for patient handling injuries but did not assess the effectiveness of an intervention to promote safe patient handling. Reference lists were reviewed for all included articles to identify additional, potentially eligible papers to be included. Studies published through October 2016 were considered for inclusion. Two reviewers (ET and SS) screened each abstract and article to determine if inclusion criteria were met. Any papers that could not be excluded using the title and abstract were reviewed at the paper level. For each included study, two reviewers (ET and SS) independently performed data abstraction and scored study and financial evaluation quality using the instrument of Tompa et al. which assesses study design, analysis methods, and presentation and discussion of results for studies of workplace ergonomic interventions.⁸ Following independent article review and data abstraction, the two reviewers met and compared abstracted findings for each article. In the case of disagreement on abstracted information, the two reviewers then went through the paper together to reach a consensus. Figure 1 presents the systematic review and article screening process.

Data Abstraction and Quality Assessment:

For each identified article, data were abstracted on publication year; study type; and facility location. Patient care level was defined as long term/rehabilitation care (LTC), hospital inpatient facilities or inpatient care units (HOSP), intensive care-only units (ICU), or mixed, for reports that combined data from multiple facilities or from separate units of multiple other types (MIX). The durations of pre-intervention and post-intervention data collection were recorded, as well as the following measures of workforce lifting hazard exposure during the study periods: patient care worked hours; staffed beds at the intervention sites; and patient-days of care provided. Program features were abstracted as binary variables indicating the presence or absence of the following: lift team; lift or weight lift limit policy; powered mobile lift introduction, and/or ceiling lift introduction. Injury counts for the pre- and post-intervention time periods were either abstracted directly or calculated from program evaluation data reported in the articles. Return on investment and payoff period calculations were noted if present. The inclusion of additional worker and patient outcome evaluations were also noted, for example worker satisfaction surveys or patient care quality studies. Study quality was assessed using the method of Tompa et al.⁸ The mean Tompa score for included studies was 54/70, standard deviation 5, where higher scores corresponded to better study quality.

Analysis:

The summary effect measure used for this analysis was the ratio of the post-intervention period injury incidence rate divided by the pre-intervention period injury incidence rate. Incidence rate ratios (IRR) less than one reflected decreased injury rates following program implementation. Pre- and post-intervention injury rates were calculated as the number of injuries per unit time standardized by the workforce at risk. Counts of injuries occurring in the pre- and post- periods were extracted directly from the included studies. The use of IRRs allowed accounting for differences in study site size by standardizing each site's number of injuries by the cumulative exposure time. Statistical significance was interpreted using a cut-off p-value of 0.05.

For studies that did not present injury count data, the number of injuries was calculated from information on injury rates, worked hours, patient beds, and/or days of care delivered. The following interrelated measures of accumulated exposure during the study periods were then used as injury rate denominators: worked hours in full time equivalents (FTE; 1 FTE = 1950 worked hours); bed-years (B-Y; 1 B-Y = 1 staffed bed for 1 year); and patient-days (P-D; 1 P-D = one patient occupying a staffed bed for one day). Worked hours, bed-years, and patient days were assumed to be linearly related according the following relationship: worked hours = care hours per patient * number of patient beds * days of follow up. For IRR calculations, when data was available for multiple possible denominators, the rate denominator was selected according to the following hierarchy: worked hours, bed-years, patient-days. Incidence rate ratios were then calculated as the ratio of rates post- to pre-intervention, creating the combined effect measure for summary comparison. IRRs were combined into a weighted average, weighted by the precision of each IRR estimate ($1/\text{variance}$). The variance was used to create 95% confidence intervals for each individual IRR.

To determine if the results were robust to the assumptions of the meta-analysis, we performed heterogeneity analyses. These included a visual examination of the funnel plot and assessment of quantitative measures of heterogeneity, including the H and I^2 statistics.⁹ The results of heterogeneity assessment using meta-regression suggested that a random effects analysis was more appropriate compared to a fixed effects summary estimate. The funnel plot had a single peak and was relatively symmetric, with a slight right skewness toward a protective effect of the intervention (Figure 2). Two studies in particular had extremely large effects: Anyan et al. 2013 had an IRR of 0.046 (33 injuries pre-intervention vs. 1 injury post-intervention) and Charney et al. 1997 Site 1 had an IRR of 0.125 (16 injuries pre-intervention vs. 2 injuries post-intervention). Quantitative measures indicated moderate to high inconsistency and heterogeneity ($I^2=0.729$ $H=1.92$ respectively). No single study or group of studies stood out in terms of influence or contribution to overall heterogeneity; the Anyan (influence = 0.00612) and Charney (influence = 0.00737) studies identified in the funnel plot were not highly influential.

A random effects analysis was conducted using restricted maximum likelihood to calculate a final combined estimate of the incidence rate ratio accounting for heterogeneity. Where studies presented data for injuries and follow up time for separate sites, each site was

included individually in the analysis, with a random effect to link together sites that came from the same study.

Meta-regression was used to examine potential sources of heterogeneity in treatment effect¹⁰ and to assess whether program components were associated with differential outcomes. Covariates selected for inclusion in the meta-regression analysis were Patient Care Level (LTC, HOSP, ICU, MIX); Program Components (lift team, ceiling lifts, mobile powered lifts, no lift team or powered lifts); and Duration of Post-Intervention Follow-Up (1 year, 1–2 years, 2–3 years, ≥3 years). Some programs included multiple components – for example, ceiling and powered mobile lifts or lift teams and powered mobile lifts. For program component comparisons, then, a single classification was assigned to each program according to the following hierarchy for lift elimination practices: any lift team, any ceiling lifts (with or without powered mobile lifts), powered mobile lifts only, or no lift team or powered devices.

Results

From 2,889 titles identified by the initial search, 27 articles reporting data from 44 intervention sites met all eligibility criteria and presented sufficient program information and evaluation data to be included in our analysis (Figure 1). Reasons for exclusion included non-intervention or patient outcome-focused SPHM studies, studies of healthcare worker injuries not related to patient handling (e.g. sharps injuries, chemical exposures, etc.), or studies of non-patient care healthcare workers (Figure 1). The most common reason for exclusion was for healthcare worker safety studies not-related to patient handling (2101 studies). The 27 papers included reported pre- and post-intervention injury data for 17 long term care sites, 20 inpatient hospital sites, and two intensive care units. Five studies reported combined data from multiple facilities or units of the other types (Table 1).

The random effects model, accounting for between-observation and between-study variability, produced a combined effects summary estimate of the IRR, including all injury rate ratios, of 0.44 (95% CI 0.36, 0.54), representing a 56% decrease in injury risk overall following SPHM program implementation ($p < 0.001$). Table 2 presents the duration of study periods, injury claim counts, and exposure measurements for the included studies.

Patient Care Level was significantly associated with program effectiveness ($p=0.01$). Among the specified care level categories, intensive care unit-only interventions had the greatest relative reduction in injury rates after program implementation (ICU IRR 0.14; 95% CI 0.07, 0.30), with hospital and long-term care facilities demonstrating lower injury reductions (LTC IRR 0.51; 95% CI 0.39, 0.66 and HOSP IRR 0.47; 95% CI 0.36, 0.60). Summary effect estimates for program impacts on injury rates are therefore presented separately according to patient care level, with the forest plots shown in Figure 3.

Significant differences in injury rate ratios were not found for varying program components targeting lift elimination: lift team (yes or no), ceiling lifts (with or without powered mobile lifts), powered mobile lifts only, or no lift team or powered devices (Figure 4).

The number of months of follow-up post-intervention was inversely associated with the injury rate ratio ($p = 0.01$), with greater program effect observed in studies with longer follow up instead of dilution of effect (Figure 4). The association between care level and program effectiveness remained statistically significant when months of follow up was included in the analysis.

Only 15 of the 27 included papers reported program costs or estimated overall financial benefits. Reported program costs varied considerably in what costs were included and whether or not costs were separated into categories such as equipment purchases, consultant fees, and training costs. And among these 15, just two studies reported on both worker injury effects and also the impact of program implementation on patient outcomes.^{11,12} Among these two studies presenting integrated program evaluations, Walden et al. reported a 38.5% decrease in employee injuries alongside a 43% decrease in hospital acquired pressure ulcers among patients following the implementation of a lift team intervention.¹¹ Additionally, Kennedy et al. reported that patient falls decreased, and they observed a 50% decrease in stage III and IV hospital-acquired pressure ulcers during the first year after program implementation.¹²

Discussion

This meta-analysis of safe patient handling program evaluations was conducted in order to estimate the quantitative impact of these programs on patient care worker injury rates and to identify program elements associated with greater efficacy. Our analysis found that safe patient handling and mobilization programs significantly decreased patient care worker injury rates. Duration of program follow up was also found to be associated with injury rate reduction, with greater reduction in injury rates observed for studies with longer follow-up periods. In addition, patient level of care was found to be associated with program effects on injury rate reduction, even after controlling for follow up duration. Across different patient care levels, the greatest reduction in injury rates occurred in intensive care units and the smallest in long term care sites. We did not identify any differences in outcomes across program implementation types.

The finding that program effectiveness differed significantly by patient level of care has several implications. In this study, the greatest injury rate reductions were observed for ICU-only interventions. Among the care levels studied, ICU patients generally require the greatest amount of mobility assistance, including frequent repositioning and transfers for patients who may be unconscious, sedated, on ventilator support, and who may be unable to cooperate with mobility assistance or have other substantial activity limitations. In the ICU setting, therefore, it is not surprising that the systematic reduction of pervasive lifting hazards through SPHM program implementation was highly effective in reducing worker injuries. In contrast, SPHM programs were found to be comparatively less effective in long term care and rehabilitation settings. Patients in these settings would be expected to be more mobile than ICU patients, but other factors which might account for the observed differences in program effectiveness include variations in staffing levels per patient, equipment suitability for the assistance tasks performed, or staff training and turnover variability.

Further studies are needed to identify comprehensive SPHM program guidelines tailored to variable patient care settings and work demands.

The findings of this study support the utility of SPHM programs in protecting patient care workers from occupational injuries. Our results build on the findings of several prior reviews related to healthcare worker musculoskeletal safety and health.^{5,13–21} A recent review by Thomas et al. outlined core program elements for successful safe patient handling and mobility programs: establishment of a safe lifting policy, performance of an ergonomic assessment, equipment availability, creation of a patient assessment protocol, staff training, and the provision of resource staff.¹⁴ Further support for comprehensive SPHM program implementation comes from a review describing the positive effects of safety and health interventions on musculoskeletal symptoms in nurses by Bos et al. in 2006¹⁹ and in healthcare settings generally by Tullar et al in 2010.⁵ Our analysis agrees with the findings of these earlier reviews and provides further support for the effectiveness of these programs by establishing a substantial and significant quantitative effect estimate for SPHM program impact on injury rates. Interestingly, in this study we did not find differences in injury rate reduction effectiveness by program type. The number of included studies may not have provided adequate power for characterizing such differences in effectiveness. Another possibility, however, is that individual facilities may have gravitated toward programs types that were best suited for their particular workplace organization and job demands.

Our review has several methodological differences compared to some previous reviews that found limited evidence to support the utility of certain interventions for reducing back pain and injury. A few earlier reviews have identified intervention strategies with limited effectiveness in reducing injuries in healthcare work settings. A 2007 review by Dawson et al. focused on the effectiveness of interventions to prevent back pain and injury in nurses. Dawson et al. concluded that strong evidence does not exist for the efficacy of interventions to prevent back pain and injury. However, Dawson's group reported conflicting evidence for the efficacy of exercise interventions and for the provision of manual handling equipment and training.¹⁸ In addition, a 2012 Cochrane Review by Verbeek et al. focused on preventing and treating back pain in workers. Verbeek et al. reported that, based on studies of moderate to very low quality, manual materials handling advice and training, with or without the introduction of assistive devices, had similar effect to no intervention, minor advice, professional education, or the use of back belts.^{15,16} A potential explanation for these findings is that a singular focus on back pain and injury excludes the full range of musculoskeletal injuries that may occur in patient care settings, particularly injuries to the shoulder and upper extremity. While strong evidence against technique-training only interventions for safe patient handling was also reported in a 2003 review by Hignett and colleagues, these authors also reported a moderate level of evidence supporting single factor interventions such as lift teams or hoist equipment programs.²⁰

This study was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)²². Included studies were identified using a defined search algorithm, and included or excluded according to our pre-specified criteria. Study data were abstracted systematically by two independent reviewers, and quantitative analysis included summary data analysis, evaluation of consistency, and assessment of risk of bias. Using a

search algorithm focused to specifically identify safe patient handling program evaluations, we found substantial and significant effects on injury rates for these programs which aim to systematically reduce patient care worker exposures to lifting hazards. A unique feature of this study is that we adapted meta-analysis methods for synthesizing the results of available pre-post program evaluation studies because of the paucity of available RCT data. Meta-analysis methods were developed for the combined evaluation of randomized controlled trial (RCT) outcome data; however, in occupational health safety interventions, randomized controlled implementations are relatively uncommon. All sites included in the combined analysis reported pre-intervention injury data, allowing each site to serve as its own control. However, it must be noted that the study sites included a number of different institutions and these varied considerably in size and services delivered. Across these different sites and for different levels of care, it would be expected that pre-intervention injury risk might differ according to differences in work processes and demands. Our analysis of the effects of SPHM program on injury rates found somewhat high inconsistency and heterogeneity ($I^2=0.729$ $H=1.92$, respectively), but this finding must be interpreted in light of the expected range of differences among the study sites. It should also be noted that no single study or group of studies stood out in terms of influence or contribution to overall heterogeneity, and the peaked and relatively symmetric funnel plot did not suggest publication bias among the included studies. We adapted meta-analysis methods to assess impacts on injury rates per worked hours in healthcare facilities of different types, with different types of interventions, and a range of follow-up evaluation periods. We report I^2 as a measure of consistency, but we did not apply a specific cutoff, given that our data was not derived from standardized, randomized, controlled trials.

While the use of pre-intervention control data might be subject to temporal bias, we believe that the risk of such bias was small, given that institutional practices and patient demographics are unlikely to change significantly within the relatively short time periods covered in these studies. Even if temporal bias did exist, our findings were strong (IRR of 0.44, 95% CI (0.36, 0.54)). Even modest bias would not be expected to change our conclusions. We believe that our adaptation of meta-analysis methods for the combined evaluation of pre-post occupational interventions represents a useful extension of these methods for the evaluation of occupational safety programs.

Among the other limitations of our analysis was that program and injury data were not reported at the individual person level. Administrative data on hours worked and staffing levels provided measures of work hazard exposure, but it should be noted that these may conceal important workforce dynamics, including employee turnover, variable staffing practices, and differences in cumulative exposure, for example between full- and part-time workers. In addition, injury rates were calculated only based on recorded work injuries, which are subject to reporting bias. Data from workers regarding self-reported musculoskeletal pain symptoms and/or unreported injuries were not available for all program evaluations. The absence of this information may have resulted in an underestimation of injury occurrences and musculoskeletal morbidity both before and after program implementation, resulting in a nondifferential effect on the findings in this study.

Among the studies included in this analysis, financial data, including program implementation costs, workers' compensation costs, and ongoing program expenses were not reported consistently. Many studies did not include any financial analysis data, while others reported only a subset of program costs (such as equipment purchases only). Only two studies reported the impact of their interventions on both worker injuries and patient outcomes; these authors reported improvements in worker injury rates, rates of hospital-acquired pressure ulcers, and patient falls following program implementation.^{11,12} The potential benefits of effective SPHM programs include not only reduced worker injuries but enhanced patient mobility assistance resulting in improved patient outcomes. SPHM programs require substantial institutional commitment for planning, equipment purchases, training, and maintenance, and this investment precedes any program benefits. More detailed information on cost and return on investment for SPHM programs would therefore be of great use in assessing plans for SPHM program development and implementation. In addition to injuries and program costs, such studies might also include productivity gains, reductions in adverse patient outcomes, and reduced job-turnover expected to occur as a result of effective SPHM program implementation. In response to the need for more comprehensive outcome evaluations for SPHM programs, Fray and Hignett developed the Tool for Risk Outstanding in Patient Handling Interventions (TROPHI), which includes organizational, staff, and patient outcome domains.²³ The broader implementation of standardized, integrated SPHM evaluation methods such as TROPHI offers promise for further determination of best practices for SPHM program effectiveness and for performance benchmarking of individual programs.

Conclusion

In this study, we found that safe patient handling and mobilization programs significantly reduce patient care worker injuries and that the beneficial effects of these programs not only persisted but improved over time. These findings provide strong support for the widespread implementation of SPHM programming in all healthcare facilities and suggest that federal legislation requiring these programs should be considered. Further research is needed to assess the combined effects of SPHM programs on worker injury rates and patient outcomes. Further determination of best practices for SPHM across variable care levels requires the widespread adoption of integrated evaluation approaches which approach healthcare worker safety alongside patient care quality improvement initiatives.

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Figure 1:
 Search and Article Selection Process

Figure 2:
Funnel plot of included study sites by $\ln(\text{injury incidence rate ratio (IRR)})$ and weight. Note the single peak and symmetry with slight right skewness.

Figure 3:

Forest Plots of Injury Incidence Rate Ratio (IRR) for Long Term Care (A), Inpatient Hospital (B), and Intensive Care Unit (C) Interventions. Circles: Lift Team Interventions; Squares: Mobile Power Lift Interventions; Triangles: Ceiling Lift Interventions; Cross: Non-power Lift Devices; Diamonds: Combined estimate values. Error bars show 95% confidence intervals. Estimates to the left of IRR=1 favor intervention as protective. Studies are listed as First Author Last Name, Publication Year, Site Number. Studies are listed alphabetically and by intervention type.

Figure 4: Injury Rate Ratios from Meta-Regression by Level of Care, Program Type, and Duration of Post-Implementation Follow Up Time. Bars show 95% confidence Intervals **p=0.01, *p=0.01

Table 1:

Characteristics of included interventions and intervention sites

Intervention site	Intervention type				Totals
	Lift Team	Powered Lift Equipment		Non-Powered Lift Assists Only	
		Mobile	Ceiling		
Long Term Care	1 ²⁴	9 ²⁵⁻²⁸	7 ²⁸⁻³⁴		17
Inpatient Hospital	11 ^{24,35,36}	3 ^{27,37,38}	5 ^{12,39-42}	1 ⁴³	20
Intensive Care Only			2 ^{44,45}		2
Mixed Care Levels	1 ¹¹	3 ^{46,47}	1 ⁴⁸		5
Totals	13	15	15	1	44

Table 2.

Duration of Study Periods, Injury Claims, and Exposure Measurements Pre- and Post-Intervention

First Author (year)	Months (Pre/Post)	Injury Claims PRE-	Injury Claims POST-	Follow Up PRE-	Follow Up POST-	Incidence Rate Ratio (95% confidence interval)
LONG TERM CARE						
LIFT TEAM						
Charney 1997 ²⁴						
Site 10	12/12	10	5	102 B-Y	102 B-Y	0.50 (0.17, 1.46)
MOBILE LIFTS						
Brophy 2001 ²⁵	24/60	60	107	382 FTE	973 FTE	0.70 (0.51, 0.96)
Collins 2004 ²⁶	36/36	129	56	921 FTE	937 FTE	0.43 (0.31, 0.58)
Evanoff 2003 ²⁷						
Site 1	12/24	64	50	928 FTE	1017 FTE	0.71 (0.49, 1.03)
Garg 2012 ²⁸						
Site 1	29/49	45	16	134 FTE	227 FTE	0.21 (0.12, 0.37)
2	30/49	60	37	160 FTE	261 FTE	0.38 (0.25, 0.57)
3	54/48	100	20	446 FTE	396 FTE	0.23 (0.14, 0.36)
4	54/48	113	36	559 FTE	497 FTE	0.36 (0.25, 0.52)
6	36/60	108	110	441 FTE	735 FTE	0.61 (0.47, 0.80)
7	36/60	27	20	124 FTE	206 FTE	0.45 (0.25, 0.80)
CEILING						
Alamgir 2008 ²⁹	72/48	422	164	2598 B-Y	1798 B-Y	0.56 (0.47, 0.67)
Chhokar 2005 ³⁰	36/36	65	47	375 B-Y	375 B-Y	0.72 (0.50, 1.05)
Engst 2005 ³¹	21/21	12	10	131 B-Y	131 B-Y	0.83 (0.36, 1.93)
Garg 2012 ²⁸						
Site 5	36/36	61	27	315 FTE	315 FTE	0.44 (0.28, 0.70)
Miller 2006 ³²	24/12	5	1	126 B-Y	63 B-Y	0.40 (0.05, 3.42)
Ronald 2002 ³³	36/19	156	81	191 FTE	105 FTE	0.95 (0.72, 1.24)
Theis 2014 ³⁴	33/48	32	33	102 B-Y	148 B-Y	0.71 (0.44, 1.16)
INPATIENT HOSPITAL CARE						
LIFT TEAM						
Charney 1997 ²⁴						
Site 1	12/72	16	2	300 B-Y	300 B-Y	0.13 (0.03, 0.54)
2	12/24	23	10	400 B-Y	400 B-Y	0.44 (0.21, 0.91)
3	12/36	45	16	200 B-Y	200 B-Y	0.36 (0.20, 0.63)
4	12/60	30	8.6	265 B-Y	265 B-Y	0.29 (0.13, 0.61)
5	12/48	173	55	420 B-Y	420 B-Y	0.32 (0.24, 0.43)
6	12/12	10	2	100 B-Y	100 B-Y	0.20 (0.04, 0.91)
7	12/6	7	2	150 B-Y	75 B-Y	0.57 (0.12, 2.75)

First Author (year)	Months (Pre/Post)	Injury Claims PRE-	Injury Claims POST-	Follow Up PRE-	Follow Up POST-	Incidence Rate Ratio (95% confidence interval)
8	12/6	36	28	220 B-Y	110 B-Y	1.56 (0.95, 2.55)
9	12/6	8	2	674 B-Y	337 B-Y	0.50 (0.11, 2.36)
Hefti 2003 ³⁵	12/24	29	22	500 B-Y	1000 B-Y	0.38 (0.22, 0.66)
Springer 2009 ³⁶	36/11	56	14	37 FTE	14 FTE	0.67 (0.37, 1.20)
MOBILE LIFTS						
Evanoff 2003 ²⁷						
Site 2	12/24	143	155	2169 FTE	2721 FTE	0.86 (0.69, 1.09)
Lynch 2000 ³⁷	36/12	94	22	1320 B-Y	440 B-Y	0.70 (0.44, 1.12)
Zadvinskis 2010 ³⁸	12/12	7	3	60 B-Y	60 B-Y	0.43 (0.11, 1.66)
CEILING						
Haglund 2010 ³⁹	35/24	43	8	968 B-Y	664 B-Y	0.27 (0.13, 0.58)
Huffman 2014 ⁴⁰	84/24	24	3	245 B-Y	70 B-Y	0.44 (0.13, 1.45)
Stenger 2007 ⁴¹	12/12	92	75	725 B-Y	725 B-Y	0.82 (0.60, 1.11)
Stevens 2013 ⁴²	12/12	22	14	29 B-Y	29 B-Y	0.64 (0.33, 1.24)
Kennedy 2015 ¹²	12/48	55	48	461 B-Y	1844 B-Y	0.23 (0.16, 0.34)
NON-POWER LIFT DEVICES						
Evanoff 1999 ⁴³	36/24	110	39	338 FTE	239 FTE	0.50 (0.35, 0.72)
INTENSIVE CARE						
CEILING						
Anyan 2013 ⁴⁴	76/43	33	1	508 FTE	333 FTE	0.05 (0.01, 0.34)
Silverwood 2006 ⁴⁵	84/24	24	3	56 B-Y	16 B-Y	0.44 (0.13, 1.45)
MIXED CARE LEVELS						
LIFT TEAM						
Walden 2013 ¹¹	12/12	13	8	47,101 P-D	59,702 P-D	0.49 (0.20, 1.17)
MOBILE LIFTS						
Li 2004 ⁴⁶	19/26	18	12	175 FTE	316 FTE	0.37 (0.18, 0.77)
Yassi 2001 ⁴⁷						
Site 1	36/12	42	13	333 FTE	123 FTE	0.84 (0.45, 1.56)
2	36/12	65	17	350 FTE	139 FTE	0.66 (0.39, 1.12)
CEILING						
Black 2011 ⁴⁸	12/12	260	151	1769 FTE	1864 FTE	0.55 (0.45, 0.67)