Paradoxical Impact of a Patient-Handling Intervention on Injury Rate Disparity Among Hospital Workers

Erika L. Sabbath, ScD, Jie Yang, PhD, MSW, Jack T. Dennerlein, PhD, Leslie I. Boden, PhD, Dean Hashimoto, MD, JD, and Glorian Sorensen, PhD

Objectives. To test whether a comprehensive safe patient-handling intervention, which successfully reduced overall injury rates among hospital workers in a prior study, was differentially effective for higher-wage workers (nurses) versus low-wage workers (patient care associates [PCAs]).

Methods. Data were from a cohort of nurses and PCAs at 2 large hospitals in Boston, Massachusetts. One hospital received the intervention in 2013; the other did not. Using longitudinal survey data from 2012 and 2014 plus longitudinal administrative injury and payroll data, we tested for socioeconomic differences in changes in self-reported safe patient-handling practices, and for socioeconomic differences in changes in injury rates using administrative data.

Results. After the intervention, improvements in self-reported patient-handling practices were equivalent for PCAs and for nurses. However, in administrative data, lifting and exertion injuries decreased among nurses (rate ratio [RR] = 0.64; 95% confidence interval [CI] = 0.41, 1.00) but not PCAs (RR = 1.10; 95% CI = 0.74,1.63; *P* for occupation × intervention interaction = 0.02).

Conclusions. Although the population-level injury rate decreased after the intervention, most improvements were among higher-wage workers, widening the socioeconomic gap in injury and exemplifying the inequality paradox. Results have implications for public health intervention development, implementation, and analysis. (*Am J Public Health.* 2019;109: 618–625. doi:10.2105/AJPH.2018.304929)

See also Galea and Vaughan, p. 541.

The workplace is an established social determinant of health.[1] Scholars have long recognized that hazardous working conditions disproportionately affect the poor and contribute to population-level health inequities.[2] Low-wage workers, non-White workers, and immigrant workers experience a higher burden of adverse occupational exposures, and subsequent risk of morbidity and mortality, than their peers.[3] Thus, the workplace can both perpetuate and exacerbate disparities.

Beginning in the 1980s, Geoffrey Rose advocated for improving public health by moving from a "high risk" approach (a biomedical model targeting those at greatest risk for disease) to a "population" approach (modifying risk factors across the population, not just for high-risk individuals).[4] In 2008, Frohlich and Potvin introduced the concept of the "inequality paradox": although "population" approaches might improve overall health by shifting disease curves to the left, they may inadvertently increase disparities if participants with more resources can better take advantage of interventions.[5] In a handful of cases, successful population-level policy changes were found to have widened health disparities,[6–9] but there are few documented instances of interventions taking place in a closed system (e.g., a workplace).[10,11] It is unclear whether this is attributable to lack of evidence of differential effects (and publication bias limiting dissemination of null results) or to lack of testing for such effects after interventions are deemed successful.

According to the Bureau of Labor Statistics, health care workers as a group have the highest reported nonfatal workplace injury rate of any industry sector—including construction, manufacturing, or transportation[12]—making them a high-priority group for health and safety interventions.[13] In particular, low-wage health care workers, such as nursing assistants, are at high risk of injury because they perform the majority of patient lifts, often alone and without equipment, training, or informal social resources to do so safely.[14] To combat this risk, many health care facilities have installed devices that aim to reduce workers' injury by providing mechanical assistance with patient lifting and repositioning. When such devices are used properly, they can reduce workers' musculoskeletal injuries,[15,16] but programs have struggled to attain consistent and universal usage of these devices because of equipment maintenance problems, lack of training, and perceived lack of management support.[17,18]

Recently, evaluation of a systems-level, hospital-based, safe patient-handling intervention[19] found that workers at the hospital that received the intervention had improved perceptions of workplace norms around safe patient handling and reduced musculoskeletal injuries. The

ABOUT THE AUTHORS

Erika L. Sabbath is with the School of Social Work, Boston College, Chestnut Hill, MA. At the time of the study, Jie Yang was with the School of Social Work, Boston College, and is also with the School of Social Work, East Carolina University, Greenville. Jack T. Dennerlein is with the Bouve College of Health Sciences, Northeastern University, Boston, MA. Leslie I. Boden is with the Department of Environmental Health, School of Public Health, Boston University, Boston. Dean Hashimoto is with Partners HealthCare, Somerville, MA. Glorian Sorensen is with the Center for Community-Based Research, Dana-Farber Cancer Institute, Boston.

Correspondence should be sent to Erika L. Sabbath, Boston College, School of Social Work, 140 Commonwealth Ave, Chestnut Hill, MA 02467 (e-mail: erika.sabbath@bc.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

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postintervention rate ratio for lifting and exertion injuries at the intervention hospital was 0.78 (95% confidence interval [CI] = 0.60, 0.89), with no changes during the same period at a similar hospital in the same health system and city.

That evaluation did not test for heterogeneity of intervention effects by worker characteristics. Understanding such heterogeneity is important because patient care associates (PCAs; low-wage patient care workers who are often non-White and foreign-born) perform more patient-handling tasks than nurses but may have had difficulty taking advantage of the intervention. If the intervention was, in fact, inadequate for vulnerable workers, we need to quantify those disparities to craft interventions that promote health equity as well as improving population health.

In the present study, we tested whether a successful occupational health intervention can have heterogeneous effects within diverse working populations by evaluating whether workers' occupation differentially shapes experience of programs, policies, and practices, and in turn produces heterogeneity in proximal and distal health outcomes as outlined in our conceptual model.[20]

We generated hypotheses based on the inequality paradox. Hypothesis 1 was that we would observe similar changes in perceptions of change in safe patient-handling practices for nurses and PCAs in the intervention hospital; on its face, the intervention would not appear to have differential effectiveness. This hypothesis was based on other studies showing that nurses and PCAs had similar perceptions of workplace policies and practices, despite their different roles and exposures.[21] Hypothesis 2, based on the inequality paradox, was that nurses would experience more decreases in self-reported pain than would PCAs after the intervention. Similarly, hypothesis 3 was that improvements in administratively reported workplace injuries as a result of the intervention would occur mainly among nurses, with fewer improvements among PCAs. The intervention would therefore increase disparities in pain and injury between higher-wage and low-wage workers.

METHODS

The study used data from the Boston Hospital Workers Health Study (BHWHS), a longitudinal cohort of hospital patient care workers at 2 large academic medical centers in Boston, Massachusetts ("intervention hospital" and "comparison hospital"). More information about the cohort is available elsewhere.[22] Although the comparison hospital had more employees, hospitals were comparable on administrative metrics, including size, types of units, case mix, and payer mix.

Hospital-based PCAs are low-wage workers, both absolutely and relative to nurses. In 2017 in the United States, their median annual wage was $30 620, less than half that of the average registered nurse and 25% above the federal poverty threshold for a family of 4.[23,24]

Intervention

Before the intervention, neither hospital had a comprehensive safe patient-handling program. In 2013, the intervention hospital began a hospital-wide safe patient-handling and mobilization program. Detailed information about the intervention itself has already been published[19]; here, we describe intervention components most relevant to the present research question.

The intervention was a multicomponent approach based on recent guidelines for safe patient-handling programs.[15,25] Program planners embedded program components and support for safe patient mobilization and handling into all levels of the organization as well as within prescribed care for the patient. The intervention was part of a larger, hospital-wide program to improve patient outcomes through early and frequent mobilization, which can reduce the adverse effects of extended bed rest and increase patient activity levels. The program committee, which was chaired by the associate chief nurse of quality, included the nursing business officer and an occupational health ergonomist. All inpatient nurse directors, who directly oversee patient care activities on their respective units, were involved in planning and implementation. Program planners integrated the intervention into the daily work of all workers, not just nurses.

The intervention was multifaceted. First, the hospital installed safe patient-handling equipment for all patient rooms and clinical areas (ceiling lifts, slings, patient transfer devices, sit-to-stand devices, floor lift devices), with the goal of improving both worker and patient safety. Second, the hospital created infrastructure to ensure that all equipment was working, that laundered slings for devices were available, and that each unit had a clear contact list for equipment problems. Third, all patient care workers (both nurses and PCAs) received comprehensive upfront and ongoing training on device use: a 1.5-hour online module complemented by group training, one-on-one coaching, at least 6 months of bedside mentoring, and instructions on all equipment. All training took place during work hours. When new staff joined the unit, they were trained in a simulation laboratory by "unit champions" who had received 2 hours of special training. Fourth, nurses integrated safe lifting and mobilization strategies into each patient's care plan, and they used electronic medical records to identify patients' mobility status and equipment needed. Program rollout began in September 2012, and worker training took place from December 2012 to April 2013 (after baseline data collection; see the next subsection). Nearly 80% of inpatient nurses and PCAs received the training.

Data Collection

In 2012 and 2014, BHWHS investigators conducted longitudinal surveys on a random subsample of one third of eligible patient care workers at both hospitals. The surveys were given before and after the intervention; the same workers were sampled at both time points. At the individual worker level, we merged survey data with data from hospital payroll records, human resources, and the occupational health department.

Although we only had survey data on sampled workers, we obtained administrative data from the entire sampling frame—all nurses and PCAs at the 2 hospitals (n = 2149 at the intervention hospital and n = 2348 at the comparison hospital at baseline).

Measures

Both 2012 and 2014 surveys measured workers' perceptions of safety practices (5 items; $\alpha = 0.93$ for nurses and 0.94 for PCAs), ergonomic practices (6 items; $\alpha = 0.87$ for nurses and 0.89 for PCAs), and safe patient-handling norms on their unit (2 items; $\alpha = 0.83$ for nurses and 0.85 for PCAs); their own safe ($\alpha = 0.83$ for nurses and 0.85 for PCAs) and

unsafe (3 items; $\alpha = 0.59$ for nurses and 0.63 for PCAs) patient-handling behaviors; number of lifts they performed per shift; and their self-efficacy to use safe patient-handling devices (3 items; $\alpha = 0.84$ for nurses and 0.79 for PCAs).[19,26,27] All α values are for 2012; reliability in 2014 was nearly identical. All scales are scored so that higher scores equal better or safer practices, with the exception of unsafe patient handling, for which higher scores equal more unsafe practices. We also measured past-month self-reported pain using a modified Nordic questionnaire,[28] and past-week pain severity using an adapted DASH questionnaire.[29–31]

From administrative human resources data, we drew employees' occupation, gender, and age. From administrative injury data, we drew injury type, cause, body part, Occupational Safety and Health Administration (OSHA) reportability (the criterion was whether an injury required time away from work or medical attention beyond first aid), and whether the worker missed work because of the injury. From weekly payroll data, we drew hours worked per week, and the unit on which people worked, to establish denominators for injury rates. We calculated those denominators by summing hours worked on a unit in a given week and converting hours to full-time equivalents.

Data Analyses

The present study aimed to test whether the intervention evaluated by Dennerlein et al.[19] was differentially effective for high-wage and low-wage workers, and then to stratify results by occupational grade.

To test hypotheses 1 and 2, we used generalized linear mixed models to account for participant-specific variation of employees who responded to both surveys. Outcomes were 7 different work practices (hypothesis 1) and 5 different pain outcomes (hypothesis 2); all outcomes were self-reported. The independent variable was time of survey. We controlled for participant-specific variation by adding employee identification number as a random effect. We added a covariate for occupation and an intervention time point × occupation interaction term to test for differences in intervention effects by occupation. We then stratified models by occupation and repeated the latter analyses separately by occupational group.

To test hypothesis 3, for each hospital separately, we generated injury counts in the preintervention and postintervention years, setting a full-time equivalent as 2000 hours per year. We used the injury database to generate injury counts and payroll data to generate the full-time equivalents. We used Poisson regression to calculate pre–post rate ratios for OSHA-recordable injuries and associated 95% confidence intervals and type III P values, with the individual worker as the unit of analysis. In these models, in addition to the main effect of intervention survey time point, we included occupation as a covariate and an interaction term for time point × occupation to test for variation in intervention effect by occupation. We repeated analyses for back injuries, lifting and exertion injuries, and pain and inflammation injuries, all of which were targets of the intervention. We then stratified the sample into nurses and PCAs. For each occupational group separately, we calculated rate ratios and associated 95% confidence intervals for changes in injury rate before and after the intervention, both for all OSHA-recordable injuries and for specific injury subtypes listed above.

As a robustness check for hypothesis 3, given the possibility of unstable interaction terms in Poisson models, we repeated

TABLE 1—Baseline Demographic and Occupational Characteristics in a Cohort of Hospital Patient Care Workers, by Hospital and Occupational Group: Boston, MA, 2012

	Intervention Hospital (n = 578)		Comparison Hospital (n = 1009)	
Variable	Nurses (Higher-Wage; n = 482), % or Mean (SD)	PCAs (Low-Wage; n = 96), % or Mean (SD)	Nurses (Higher-Wage; n = 915), % or Mean (SD)	PCAs (Low-Wage; n = 94), % or Mean (SD)
Gender				
Male	6.16	8.6	6.68	25.1
Female	93.84	91.4	93.32	74.9
Age, y	42.61 (11.45)	43.52 (12.28)	40.61 (12.22)	39.94 (12.33)
Typical shift worked				
Day	35.76	34.74	20.49	35.06
Evening	4.78	18.95	4.38	17.75
Night	32.64	25.26	21.95	13.34
Other	26.82	21.05	53.17	33.77
Race/ethnicity				
Hispanic/Latino	2.32	23.66	1.21	19.23
Non-Hispanic White	86.92	18.28	87.1	39.74
Non-Hispanic Black	5.06	52.69	4.05	28.21
Mixed race/other	5.7	5.38	7.54	12.82

Note. PCA = patient care associate. Eight units at the comparison hospital participated in an unrelated proof-of-concept trial for a health promotion program. In that trial, all workers in the 8 units were sampled, rather than the one third sampling fraction used for other units. We therefore have weighted descriptive statistics to account for overrepresentation of workers in those units.

TABLE 2—Pre–Post Comparison of Self-Reported Work Practices and Patient-Handling Behavior Among Hospital Patient Care Workers, by Wage Level: Boston, MA, 2012 and 2014

	Higher-Wage Workers (Nurses)			Low-Wage Workers (PCAs)			
Variable	Baseline Adjusted Mean (SE)	Follow-Up Adjusted Mean (SE)	Adjusted Mean Difference (95% CI)	Baseline Adjusted Mean (SE)	Follow-Up Adjusted Mean (SE)	Adjusted Mean Difference (95% CI)	*P* for Occupation × Intervention Interaction
Intervention hospital[a]							
SPH (1–5; higher = better)	2.16 (0.06)	2.50 (0.06)	0.33 (0.24, 0.42)	2.59 (0.15)	3.08 (0.15)	0.48 (0.19, 0.77)	.22
Unsafe patient handling (1–5; higher = worse)	2.12 (0.04)	1.98 (0.04)	−0.14 (−0.22, −0.07)	2.42 (0.12)	2.50 (0.12)	0.08 (−0.18, 0.34)	.041
No. of lifts per shift	11.70 (0.43)	10.71 (0.43)	−0.99 (−1.79, −0.20)	14.62 (1.32)	12.49 (1.32)	−2.12 (−4.48, 0.23)	.31
Self-efficacy to use SPH devices (1–5; higher = better)	3.45 (0.07)	3.38 (0.07)	−0.06 (−0.18, 0.04)	3.73 (0.16)	3.52 (0.16)	−0.21 (−0.54, 0.11)	.31
Unit safety practices (1–5; higher = better)	3.53 (0.04)	3.55 (0.04)	0.02 (−0.05, 0.09)	3.73 (0.10)	3.84 (0.10)	0.11 (−0.08, 0.31)	.32
Unit ergonomic practices (1–5; higher = better)	2.91 (0.04)	3.00 (0.04)	0.10 (0.02, 0.18)	3.60 (0.11)	3.63 (0.11)	0.03 (−0.22, 0.27)	.61
Comparison hospital[b]							
SPH (1–5; higher = better)	2.32 (0.04)	2.35 (0.04)	0.02 (−0.04, 0.09)	2.97 (0.16)	2.84 (0.16)	−0.13 (−0.39, 0.13)	.18
Unsafe patient handling (1–5; higher = worse)	2.11 (0.02)	2.16 (0.03)	0.05 (0.00, 0.10)	2.46 (0.10)	2.41 (0.11)	−0.05 (−0.27, 0.17)	.26
No. of lifts per shift	11.96 (0.31)	11.87 (0.31)	−0.09 (−0.59, 0.41)	14.27 (1.64)	14.81 (1.63)	0.53 (−1.95, 3.02)	.50
Self-efficacy to use SPH devices (1–5; higher = better)	3.63 (0.05)	3.54 (0.05)	-0.09 (−0.16, −0.02)	3.73 (0.15)	3.64 (0.15)	−0.08 (−0.38, 0.21)	.91
Unit safety practices (1–5; higher = better)	3.90 (0.03)	3.80 (0.03)	−0.09 (−0.15, −0.04)	3.91 (0.10)	3.81 (0.10)	−0.10 (−0.35, 0.14)	.96
Unit ergonomic practices (1–5; higher = better)	3.13 (0.03)	3.11 (0.03)	−0.02 (−0.08, 0.04)	3.56 (0.11)	3.46 (0.11)	−0.10 (−0.28, 0.09)	.48

Note. CI = confidence interval; PCA = patient care associate; SPH = safe patient handling. All models are adjusted for random employee effect to control for participant-specific variation of employees who responded to both surveys.

[a]At baseline, the sample comprised 482 nurses and 96 PCAs.

[b]At baseline, the sample comprised 915 nurses and 94 PCAs.

occupation × intervention interaction analyses, specifying a negative binomial instead of a Poisson distribution.

For all hypotheses, we conducted analyses for intervention and comparison hospitals separately. We conducted analyses for hypotheses 1 and 2 using Stata/SE version 15 (StataCorp LP, College Station, TX), and analyses for hypothesis 3 using SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Overall, 578 workers at the intervention hospital (482 nurses and 96 PCAs) responded to the 2012 (baseline) survey. At the comparison hospital, 1009 workers responded at baseline (915 nurses and 94 PCAs). The overall response rate was 75% in 2012 (77% for nurses, 61% for PCAs) and 72% in 2014 (74% for nurses, 57% for PCAs). Although the social and demographic characteristics of nurses across the 2 hospitals were similar (Table 1), PCAs at the intervention hospital were more racially and ethnically diverse (18% non-Hispanic White at the intervention hospital vs 40% at the comparison hospital).

At the intervention hospital, both nurses and PCAs reported improvement in safe patient-handling practices (e.g., using lifting devices to boost patients in bed) after the intervention; adjusted mean difference was 0.33 (95% CI = 0.24, 0.42) among nurses and 0.48 (95% CI = 0.19, 0.77) among PCAs (Table 2). PCAs also reported a nonsignificant decrease in number of lifts per shift (from 14.62 to 12.49; $P = .08$). The decrease was statistically significant among nurses (from 11.70 to 10.71; $P = .01$).

We observed disparities in change to unsafe patient-handling behaviors (e.g., transferring patients without using lifting devices). A negative value for change represents improvement. Among nurses, the change was −0.14 (95% CI = −0.22, −0.07), whereas among PCAs there was no change (0.08; 95% CI = −0.18, 0.34); P for occupation × intervention interaction = .04). We observed some small, although statistically significant, declines in unit safety practices and self-efficacy to use equipment among nurses (but not PCAs) at the comparison hospital.

TABLE 3—Pre–Post Comparison of Self-Reported Pain Among Hospital Patient Care Workers, by Wage Level: Boston, MA, 2012 and 2014

Variable	Higher-Wage Workers (Nurses)			Low-Wage Workers (PCAs)			*P* for Occupation × Intervention Interaction
	Baseline Adjusted % (SE)	Follow-Up Adjusted % (SE)	AOR (95% CI)	Baseline Adjusted % (SE)	Follow-Up Adjusted % (SE)	AOR (95% CI)	
Intervention hospital							
Any pain	82.09 (0.02)	78.34 (0.02)	0.67 (0.41, 1.08)	74.94 (0.05)	70.48 (0.05)	0.67 (0.24, 1.87)	.99
Low back pain	54.95 (0.03)	50.73 (0.03)	0.75 (0.51, 1.10)	51.57 (0.06)	46.87 (0.06)	0.77 (0.34, 1.75)	.95
Shoulder/neck pain	45.92 (0.03)	40.38 (0.03)	0.69 (0.47, 1.01)	34.28 (0.06)	43.64 (0.06)	1.86 (0.74, 4.64)	.048
Pain interference with work	28.57 (0.02)	27.21 (0.02)	0.91 (0.61, 1.35)	35.63 (0.06)	37.45 (0.06)	1.15 (0.43, 3.03)	.68
Moderate or severe pain level	44.69 (0.03)	41.43 (0.03)	0.79 (0.53, 1.18)	52.61 (0.07)	55.03 (0.06)	1.20 (0.45, 3.18)	.45
Comparison hospital							
Any pain	77.98 (0.02)	75.72 (0.02)	0.82 (0.61, 1.11)	75.63 (0.05)	77.19 (0.05)	1.19 (0.40, 3.59)	.52
Low back pain	54.67 (0.02)	52.85 (0.02)	0.89 (0.68, 1.16)	50.75 (0.06)	52.24 (0.06)	1.08 (0.49, 2.37)	.64
Shoulder/neck pain	42.45 (0.02)	38.72 (0.02)	0.78 (0.60, 1.02)	38.58 (0.06)	37.10 (0.06)	0.90 (0.37, 2.21)	.76
Pain interference with work	23.92 (0.02)	23.68 (0.02)	0.98 (0.72, 1.32)	37.65 (0.06)	34.74 (0.06)	0.83 (0.34, 2.01)	.73
Moderate or severe pain level	38.39 (0.02)	39.15 (0.02)	1.06 (0.80, 1.40)	51.78 (0.06)	59.81 (0.06)	1.66 (0.69, 4.01)	.30

Note. AOR = adjusted odds ratio; CI = confidence interval; PCA = patient care associate. All models are adjusted for random employee effect to control for participant-specific variation of employees who responded to both surveys.

As in the overall sample,[19] self-reported pain remained unchanged for both nurses and PCAs at the intervention hospital and the comparison hospital (Table 3).

Among nurses, the pre–post rate ratio for all OSHA-recordable injuries was 0.82 (95% CI = 0.70, 0.96), whereas among PCAs the corresponding figure was 1.06 (95% CI = 0.81, 1.37; *P* for occupation × intervention interaction = .11; Table 4).

We observed statistically significant occupation × intervention interactions for injury types and causes specifically targeted by the intervention. For back injuries, the pre–post rate ratio was 0.66 (95% CI = 0.49, 0.90) among nurses and 1.45 (95% CI = 0.82, 2.57) among PCAs (*P* for occupation × intervention interaction = .019). For lifting and exertion injuries, the rate ratio was 0.64 (95% CI = 0.41,1.00) among nurses and 1.10 (95% CI = 0.74,1.63) among PCAs (*P* for occupation × intervention interaction = .019). At the comparison hospital, we found no significant changes in injury for either nurses or PCAs, and no occupation × intervention interactions.

As a robustness check, we fit the occupation × intervention interaction models in Table 4 specifying a negative binomial instead of a Poisson distribution. The statistical significance of interaction terms and conclusions remained unchanged.

DISCUSSION

We reanalyzed data from an occupational safety and health intervention[19] to test whether, despite being successful at the population level, the intervention may have inadvertently widened the health gap between higher-wage workers (nurses) and low-wage workers (PCAs), a phenomenon known as the inequality paradox.[5] We found that although the intervention changed self-reported perceptions of safe patient handling in both nurses and PCAs, it produced concomitant reductions in injuries only in nurses. It had no significant effects on any pain or injury endpoint in PCAs. Findings have implications for intervention planning, implementation, and evaluation.

Limitations and Strengths

By its nature, our analysis involved many statistical tests and multiple comparisons, which could lead to some results being significant purely by chance. However, when results are viewed as a whole (particularly Table 4), they are consistent in magnitude and direction as well as significance. We were also unable to do a difference-in-difference model with both hospitals in the same analysis because this was not designed as a trial; therefore, we refer to the second hospital as "comparison" instead of "control." The comparison hospital results provide evidence that findings were not due to history or contextual effects. Although we cannot account for all potential explanations for our findings, the use of a pre–post design and a concurrent comparison reduces many sources of bias.

Both hospitals had fewer PCAs than nurses (Table 1); it is therefore possible that our stratified analyses of PCAs were underpowered to detect effects, leading to type II error. We might have detected more—or, potentially, fewer—disparities if our sample of PCAs had been larger. Another limitation is that we cannot definitively determine reasons for the disparity in intervention effectiveness; in consultation with hospital staff who administered the intervention and researchers that performed the initial evaluation, we have made data-informed hypotheses.[19] Qualitative interviews with both nurses and PCAs at the end of the program could have helped provide more direct explanations.

TABLE 4—Pre–Post Comparison of OSHA-Recordable Injury Rates Among Hospital Patient Care Workers, by Wage Level: Boston, MA, 2012 and 2014

Variable	Higher-Wage Workers (Nurses)			Low-Wage Workers (PCAs)			*P* for Occupation × Intervention Interaction
	Preprogram Injury Rate/100 FTE (95% CI)	Postprogram Injury Rate/100 FTE (95% CI)	Rate Ratio (95% CI)	Preprogram Injury Rate/100 FTE (95% CI)	Postprogram Injury Rate/100 FTE (95% CI)	Rate Ratio (95% CI)	
Intervention hospital							
All injuries	20.78 (18.68, 23.11)	16.98 (15.09, 19.10)	0.82 (0.70, 0.96)	21.05 (17.45, 25.40)	22.20 (18.44, 26.74)	1.06 (0.81, 1.37)	.11
Body part: back injuries	6.19 (5.09, 7.52)	4.11 (3.23, 5.22)	0.66 (0.49, 0.90)	3.86 (2.49, 5.99)	5.60 (3.87, 8.11)	1.45 (0.82, 2.57)	.019
Cause: lifting or exertion	11.71 (10.16, 13.49)	7.54 (6.32, 9.00)	0.64 (0.41, 1.00)	9.27 (6.99, 12.30)	10.20 (7.75, 13.42)	1.10 (0.74, 1.63)	.021
Nature: pain or inflammation	7.78 (6.54, 9.26)	5.58 (4.54, 6.85)	0.72 (0.55, 0.94)	5.02 (3.42, 7.37)	5.60 (3.87, 8.11)	1.12 (0.65, 1.90)	.15
Comparison hospital							
All injuries	6.94 (5.87, 8.21)	6.07 (5.09, 7.25)	0.88 (0.69, 1.12)	16.03 (12.45, 20.65)	14.67 (11.31, 19.02)	0.92 (0.64, 1.31)	.84
Body part: back injuries	1.22 (0.82, 1.81)	1.28 (0.87, 1.89)	1.06 (0.61, 1.84	2.40 (1.25, 4.62)	1.03 (0.39, 2.74)	0.43 (0.13, 1.39)	.17
Cause: lifting or exertion	2.23 (1.66, 3.00)	1.88 (1.37, 2.58)	0.84 (0.55, 1.30)	3.21 (1.82, 5.65)	2.57 (1.38, 4.78)	0.80 (0.35, 1.86)	.92
Nature: pain or inflammation	1.72 (1.23, 2.41)	1.23 (0.83, 1.83)	0.72 (0.43, 1.20)	2.14 (1.07, 4.27)	1.03 (0.39, 2.74)	0.48 (0.15, 1.60)	.55

Note. CI = confidence interval; FTE = full-time equivalent; OSHA = Occupational Safety and Health Administration; PCA = patient care associate. OSHA-recordable injuries are injuries that require medical attention beyond first aid, time away from work after the day of the injury, or both. OSHA-recordable injuries are tracked by the occupational health departments at the hospitals.

The study also has strengths. We took full advantage of the integrated nature of the BHWHS.[22] In this case, the ability to merge longitudinal survey data, injury data from the occupational health department, occupation data from human resources, and hours worked from payroll data enabled analysis of intervention disparities that would been masked with only survey data, as seen with pain analyses in Table 3. Comparability and geographic proximity of the intervention and comparison hospitals, identical data structures for both hospitals, and both hospitals being part of the same health system, strengthened the concurrent comparison.

Possible Explanations for Findings

In Table 2, both nurses and PCAs reported some improvements in safe patient-handling activities after the intervention. Universal improvements in safe patient-handling activities suggest that intervention messages did reach all workers as intended. We did, however, observe disparities in reduction of unsafe handling practices, with nurses (but not PCAs) significantly decreasing such practices; differential changes in unsafe patient handling may have contributed to the injury disparity, with nurses reducing unsafe practices more than PCAs.

Some explanations for our findings involve the intervention itself. The intervention took a systems approach: nurses and PCAs received identical training, messaging, and support. However, some day-to-day components of the intervention (e.g., patient mobilization planning) were part of the nurses' roles. Nurses may have absorbed more intervention messages because they were more deeply engaged in parts of its implementation.

Other explanations involve differences in hospital work organization and the nature of nurses' and PCAs' jobs. At both hospitals, PCAs performed more lifts per shift than nurses both before and after the intervention. Much patient lifting and repositioning that PCAs perform is unplanned, and therefore PCAs may have more difficulty following safe patient-handling practices promoted by the intervention, such as team lifts. Because PCAs may have less informal social capital than nurses because of strict social hierarchies in hospital settings as well as broader social dynamics of race and class,[32,33] they may also be less willing or able to ask colleagues for help. These barriers could hinder consistent use of lifting devices.

It is possible that improvements in injury rates among PCAs could have been masked if the intervention indirectly encouraged injury reporting by improving the safety climate. Although we did not measure safety climate per se, we did measure safety and ergonomic practices as indicators of whether the intervention influenced workers' perceptions about leadership commitment to improving working conditions. In Table 2, we did not see significant improvements in perceptions of ergonomic practices or safety practices among PCAs, which weakens this explanation.

There is also evidence that occasional or inconsistent use of a lifting device is associated with worse musculoskeletal outcomes than no use.[17] If, owing to aforementioned aspects of the PCA role, PCAs use lifting devices only occasionally, improvements in injury rates may have been offset by increased injury risk due to users' unfamiliarity. This explanation is especially salient given our finding that PCAs did report improvements in their patient-handling practices, but did not have reductions in injuries.

Our findings advance literature on occupational health disparities and the differential effectiveness of occupational health initiatives.[10,34] Much of the latter literature is either observational or conceptual, demonstrating the need for culturally tailored interventions but not explicitly testing whether existing interventions are inadequate for certain groups. This is one of the first studies to empirically examine whether worker vulnerability (here, socioeconomic status) shapes the

effectiveness of occupational health interventions.

Public Health Implications

In addition to specific lessons for safe patient-handling interventions, the study raises uncomfortable questions for public health interventions in general. In how many other interventions, celebrated as successfully improving population-level health, are social disparities in intervention efficacy hiding in plain sight? Of course, many workplace interventions take place in workforces composed entirely of low-wage workers. Those interventions, by design, aim to reduce population-level disparities by improving health in disadvantaged groups.[35] However, when interventions are conducted within diverse populations, the present study demonstrates the necessity of analyzing (inadvertent) disparities in intervention uptake or outcomes as a standard part of evaluation. In the planning stage, scholars should explicitly design interventions to minimize disparities in uptake or effectiveness. Analyses aimed at detecting the presence of the inequality paradox should be specified a priori and, if feasible, interventions should be powered to detect such disparities.

On the basis of these findings, we urge other scholars to reanalyze data from successful interventions, as was done here, to test for the inequality paradox. If such disparities are detected, it will be an opportunity to revise approaches to intervention planning, implementation, and evaluation. Such revisions will ensure that we are not sacrificing health equity in the service of improving health at the population level. AJPH

CONTRIBUTORS

E. L. Sabbath generated hypotheses, performed analyses for Table 4, and drafted the manuscript. J. Yang performed analyses for Tables 1 through 3 and edited the manuscript. L. I. Boden, J. T. Dennerlein, D. Hashimoto, and G. Sorensen collaborated on the research plan, helped interpret findings, and edited the manuscript. J. T. Dennerlein and D. Hashimoto also provided substantive knowledge about the intervention and its initial evaluation.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

HUMAN PARTICIPANT PROTECTION

The study was approved by the Human Research Committee at Partners HealthCare.

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