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Forklift Safety – Pilot Study Evaluation of Retrofit Lights

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In Brief

• Blue and red lights were retrofitted onto three forklifts and used for four months in a warehouse environment to increase the awareness of approaching vehicles.

• A short list of open-ended discussion questions pertaining to the retrofit lights was administered to nine employees who were operators and pedestrians.

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Bio Sketches for Authors

Thomas G. Bobick, Ph.D., P.E., CSP, CPE is a Research Safety Engineer with the Division of Safety Research (DSR) at the National Institute for Occupational Safety and Health (NIOSH) with the Centers for Disease Control and Prevention (CDC) in Morgantown, WV. He has a Doctorate in Industrial Engineering, specializing in Ergonomics, from West Virginia University, a Master's in Industrial Hygiene from the University of Pittsburgh's Graduate School of Public Health, and an undergraduate degree in Mining Engineering from Penn State University. Bobick has been the NIOSH representative to the ANSI/ASSP A10 Standards Committee for Safety Requirements in Construction and Demolition Opera-tions since 2005. He is a professional member of ASSP's Greater West Virginia Chapter and a member of the Engineering, Construction, and Ergonomics Practice Specialties. In 2013, Bobick was selected as CDC's Federal Engineer of the Year. In 2016, he was selected as Safety Professional of the Year (SPY) in the Construction Practice Specialty of ASSP. From 2014-2018, he served on ASSP's Standards Develop-ment Committee. During the past 10 years, his research efforts have been directed toward preventing forklift-related traumatic injuries and preventing workers from falling from elevated work sites.

Mathew Hause is a senior research safety engineer for the Human Factors Team, DSR, NIOSH in Morgantown, WV. As a safety engineer with 28 years' experience, he is responsible for developing and planning intramural and extramural laboratory and field research studies. He provides technical assistance to both internal and external customers on a variety of research topics related to traumatic injuries. Current research involves 3D anthropometry of Law Enforcement Officers, falls from elevation in construction, and forklift safety. Hause is a Lt. Commander in the U.S. Public Health Service and has a strong interest in the incident command structure and National Public Health Strategies. He has a B.S. in Industrial Engineering from West Virginia University.

Christina Socias-Morales, DrPH graduated with a Doctorate of Public Health in Environmental and Occupational Health Sciences from the University of Texas School of Public Health. She served as an Epidemic Intelligence Officer at DSR, NIOSH, CDC from 2013-2015, where she assisted with domestic and international outbreak investigations. She has continued at DSR as a Research Epidemiologist and focuses her research on occupational injuries including fall injuries, violence, health disparities, forklift injuries, Department of Defense collaborations, and surveillance systems such as electronic health records, surveys, and workers' compensation systems.

Melody Gwilliam is an Epidemiologist for the Analysis and Field Evaluations Branch, DSR, NIOSH in Morgantown, WV. She has worked with DSR for 6 years on a variety of projects focused on occupational injuries. She holds a Master's in Journalism and Master's in Public Health from West Virginia University (WVU). She also worked as an Epidemiologist for the state of West Virginia for 5 years. She is currently working on her Doctorate in Epidemiology from WVU.

Tashira Decker is a Senior Health Safety and Environment (HSE) Advisor for Bombardier Transportation (12 years). She holds a B.S. in Environmental Health Science from the University of Georgia and a Master's degree in Environmental Science Management from Duquesne University.

• Feedback indicated that all nine employees thought the addition of the lights increased the visibility of the forklifts and improved safety by making the vehicles more conspicuous.

Forklift vehicles are important for numerous U.S. industries. From 2009 to 2018, slightly less than 1.7 million powered industrial trucks, including forklifts, were shipped from manufacturers to customers in the United States (Industrial Truck Association, 2019). Forklifts are used to move supplies and products throughout facilities and onto tractor-trailer vehicles for delivery to customers nation-wide. For each forklift being used, there are usually one or two pedestrian workers in the same area who are exposed to the mobile forklifts. Thus, there are numerous pedestrian workers who are at risk of being injured, sometimes fatally. The initial research conducted on forklifts by the National Institute for Occupational Safety and Health (NIOSH) has indicated that forklift injuries and fatalities were mainly due to vehicle overturns, and bystander (pedestrian worker) struck-by events and crushed-by-forklift events (NIOSH, 2001).

Since 1980, there has been an increase in fatal forklift injuries with about 73 fatalities annually from 1980 to 1994 (Collins et al., 1999) to an average of 86 fatalities annually from 2013 to 2017 (Bureau of Labor Statistics, 2015, 2016, 2017, 2018, 2019). This 18% increase may be due to improvements in traumatic occupational fatality monitoring, or to more forklifts or employees in the workplace. Regardless, it is indicative of a persistent occupational hazard. Table 1 presents the number of fatal injuries caused by forklifts, which includes order pickers and powered platform trucks, during the period 2013 to 2017. It is important to note that the primary source of the fatality and the secondary source of the fatality are mutually exclusive and cannot be combined to obtain a yearly total. Table 1 also presents forklift-related non-fatal injuries involving days away from work (DAFW). For the 5-year period, 2013 through 2017, an annual average of more than 7,100 forklift injuries occurred involving DAFW. As an indication of severity, for that same 5-year period, an annual average of 2,732 (or 38%) of all forklift injuries involved workers missing 31 or more DAFW. Assuming a 5-day work week, this is more than six work weeks missed for each of those 2,732 forklift-related injuries. Several different types of forklifts are used in indoor and outdoor settings across all U.S. industries. The focus of this pilot study is electric stand-up forklifts.

Research Study

A small pilot study was conducted by the Division of Safety Research, NIOSH, Morgantown, WV. The goal of the pilot study was to evaluate commercial safety products that were installed on a convenience sample of three electric stand-up forklift vehicles that were operational. These retrofit safety products were evaluated during normal work activities to determine whether they enhanced the safety of the overall work environment. The cooperating company granted NIOSH researchers access to the workplace to collect photos of the operating vehicles and to eventually collect feedback from nine employees about the modifications. During the visits, the researchers were able to observe any obvious reactions from pedestrian workers to the retrofit safety lights.

Discussions with the distributor of Hyster-Yale forklifts in the southwestern PA area led to the identification of a customer who was interested in cooperating with NIOSH in the safety evaluation study. That customer was Bombardier Transportation, a Canada-based manufacturer of air and rail transportation equipment. Bombardier has a plant located in the Pittsburgh area (West Mifflin, PA) that is focused on rail transportation. Bombardier had recently ordered three new forklift vehicles and were interested in cooperating with NIOSH to evaluate retrofit safety products on those forklifts.

After discussing the planned testing, Bombardier agreed to cooperate with NIOSH. Before beginning the study, a training session was conducted by personnel of the forklift distributor for the four NIOSH researchers. The training included a morning session on terminology, differences among the various forklift models, functionality of the different vehicles, and specific operating techniques for the sit-down and stand-up vehicles that are being operated at the Bombardier plant. The afternoon session consisted of hands-on operation by the NIOSH researchers of both the sit-down and stand-up models in use at the plant.

After the training session, two of the NIOSH researchers made arrangements with Bombardier personnel to observe the operations of the three new stand-up forklift vehicles at the West Mifflin plant during 2017 and 2018. Three visits, conducted during July, August, and September 2017, provided NIOSH researchers an opportunity to become familiar with the plant operation. The first retrofit modification, which occurred in October 2017, involved installing a blue light on the front of the overhead protection on all three forklifts (Figure 1). A follow-up visit was conducted in January 2018 to observe vehicle usage with the blue lights in the forward direction. The second modification completed by the forklift distributor's technician occurred in March 2018, and involved the installation of the second blue light on the rear of the canopy for all three forklifts (Figure 2). Follow-up visits occurred during May and June 2018. Finally, the third modification occurred in August 2018 and consisted of installing red lights (Figure 3) on both sides of the three forklifts to provide an indication of the turning radius (rear-end swing) as a warning to pedestrian workers. Two follow-up visits were scheduled when both blue and red lights were installed. These occurred during August and September 2018.

The three stand-up forklifts evaluated were used for a combined total of 1,259 hours over the course of the 14-month pilot study. During the eight site visits, the researchers observed order pickers and pedestrians in close proximity to the forklifts during the various stages of adding blue lights and red lights to the three stand-up forklifts for safety warning purposes.

Installing the lights incrementally allowed operators, pedestrians, and researchers to become familiar with the newest addition before the next set of lights were added. The next section will discuss the costs associated with the installation of the lights.

Costs

The cost of each of the lights (both blue and red) was about $200. There were four lights for each forklift for a total of $800 in components. A service contract with the local forklift distributor was prepared that included the cost of the lights and the labor to install them

being paid for by the NIOSH pilot project. Because the lights were installed in three stages, there were three charges for labor with one charge for each separate installation. Labor costs for each installation was about $200 each, for a total of $600 in labor for each vehicle. The total cost (parts and labor) of installing the retrofit lights was $1400 per forklift. The cost of parts and labor for installing the retrofit lights would be about 4.0% to 4.5% of the estimated cost of a new forklift similar to the vehicles used in this pilot study. Of course, if all four lights were installed at the same time, there would be only one labor charge, instead of three.

Employee Feedback

On the last day that the researchers visited the plant (Sept 25, 2018), some basic questions were asked of nine employees – four operators, three pedestrians, and two supervisors. Most of the questions were related to their reactions to the blue and red lights installed on the forklifts. In addition to questions about the lights, the researchers asked participants if they had any ideas on how to improve safety even more. A summary of the responses is presented next. The questions were asked only when those individuals had some momentary downtime, and the total time to answer the questions was less than 10 minutes per person.

Operators

The total experience for the four operators ranged from two to 42 years, with the average being 14.5 years. This was career experience, not just with Bombardier. All four operators thought the lights helped to warn other workers in the area. Specifically, two of the operators preferred just the two blue lights, and the other two operators preferred both blue and red lights on the vehicles. Three of the four operators felt that if they had to operate a forklift not equipped with any blue or red lights, they would want their company to add them. In general, all four of the operators felt that the addition of the lights helped with safety. Conversely, two of the four operators felt that, when approaching the metal racks, the front blue light caused some slight glare by reflecting off the metal vertical supports, and more glare when reflecting off the plastic shrink-wrap. They felt that this momentary glare was a negative aspect of the front light. A third operator felt that the location of the red lights at the front of the canopy contributed negatively because of shining in his eyes when looking at the upper shelves.

The last question asked of everyone was whether they had any ideas to increase safety overall. One operator suggested that additional training on forklift operation could contribute to consistency, and another operator suggested that an improvement would be to use the vehicle hydraulics to automatically move the forks left and right, instead of doing it manually with the potential for a back injury.

Pedestrian Workers

Three pedestrian workers were interviewed. One of them had never been an operator. The other two still are operators, even though they weren’t operating that day. Their career experience as forklift operators was 18 and seven years. Again, this experience includes time beyond their tenure with Bombardier. For the questions related to their reaction to the blue

and red lights, all three felt that the addition of the lights helped to warn workers in the area. Two of the pedestrians preferred it when both the blue and red lights were on the vehicles. The third pedestrian preferred just the blue lights. All three of the pedestrians generally felt that the addition of the lights helped with safety. When asked if the lights had a positive or negative effect doing their jobs, two commented that they felt the lights had a positive effect, and the third employee, who was primarily an operator, also felt that the lights caused glare. Concerning the last question on additional ideas for safety, two of the pedestrians commented that the drivers needed to drive the forklifts more slowly. The third pedestrian mentioned that padding is needed on unguarded corners of the storage racks.

Supervisors

Two supervisors were interviewed. Their supervisory experience ranged between seven and 12 years. One had been an operator previously for 15 years; the other had not been an operator. Both supervisors preferred the vehicles with both the blue and red lights installed. One supervisor felt that, as a pedestrian, adding the blue lights improved safety, and by adding the red lights, they made the forklifts even more visible. When asked about receiving any feedback from the workers regarding the lights, one supervisor mentioned the problem of glare already identified by the workers. However, one supervisor mentioned that in the beginning of the study, the lights made the vehicles more noticeable, but later they became “part of the norm”. That was surprising since the research team had not heard that from any of the other workers interviewed. Unfortunately, the researchers could not follow up on that observation, since it was at the end of the shift on the last day of the visits.

Regarding the question on additional ideas for overall safety, one supervisor commented that the vehicles should be operated at a slower speed and that the operator should not have the option to change the speed. The other supervisor provided comments regarding the additional safety efforts that Bombardier has implemented, including having a 10-minute daily morning meeting that includes talking about safety first, and that everyone attending the meeting has to contribute. Managers are required to do a monthly walk-through, and the company uses a Dangerous Concerns/Near Miss form to encourage input from workers about how to improve safety. These forms are used together by management and the reporting employees to ensure that concerns are addressed and changes are incorporated to make the workplace safer.

Discussion

The blue lights were well-received by the employees who answered our questions, and they felt the lights provided extra warning to pedestrian workers and other vehicle operators. Regarding the issue of glare, the research team suggested to the forklift manufacturer’s technical sales representative the idea of automatically dimming the front blue light when the forklift is paused to remove or place a load on the racks. The response was it might work, but would require modifying the wiring by the manufacturer, and may be viewed as too costly. The location of the red lights was also a problem, but that has already been remedied by the forklift distributor by moving the location of the red lights toward the rear of the canopy, thus eliminating the glare.

Forklift operators are evaluated every three years, as required by OSHA regulations. Both supervisors commented that every three years is adequate for most workers, although if an incident does happen, then additional training will be required. In addition, evaluation training can be scheduled even before the three-year time period, if needed. The NIOSH research team suggested that refresher training should be conducted every 12 to 18 months, especially if an employee is an infrequent operator. Complacency can lead to taking short-cuts, which may contribute to hazardous actions.

Speed of vehicle operation was mentioned by the pedestrians and a supervisor as an area of concern. There are three speeds indicated on the vehicles (simply 1, 2, and 3). Corresponding speeds (ft/min or mi/hr) were not designated on the vehicles. The NIOSH research team suggests that vehicles should be operated at the slowest speed. Also, the proper technique is to tilt the forks upward before moving, which is company policy, to stabilize the load against the back rest when transporting a load. Despite these minor observations, the operation of the West Mifflin Plant was well-run with workers who were conscientious and safety-conscious.

Conclusions

All nine of the employees questioned thought the addition of the lights increased the visibility of the forklifts and improved safety in the work area by making the vehicles more conspicuous. Six employees questioned preferred the combination of blue and red lights. The other three employees preferred only the blue lights.

Since the use of the lights was well-received by the operators and pedestrians, Bombardier should continue using the blue and red lights at the current location. If company management agrees, blue and red lights could be used in other plant locations in the United States, or even world-wide, for safety purposes. Future studies should include more employees and management, longer observation periods, and more in-depth feedback about adding lights to the forklifts.

Not enough information is available about the use of retrofit lights on existing forklifts. Because of this lack of information, it would be beneficial to other safety professionals if the unsafe situations, which might be avoided in the future because of using the lights, could be documented and then published in a safety-related journal to help educate others in the safety community.

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Figure 1.
Single forward-facing blue light installed.

Figure 2.
Forward- and rear-facing blue lights installed.

Figure 3.
Red lights installed on each side, with the front blue light visible on the storage rack and the rear blue light visible on the floor (right edge of photo).

Table 1.

Forklift[a]-related occupational fatalities by primary and secondary sources of fatality, and forklift-related occupational injuries involving days away from work (DAFW) by source of injury, all U.S. private industries, 2013–2017 [b]

Fatality Source [c]	**2013**	**2014**	**2015**	**2016**	**2017**	**Avg for 5 yrs**
Primary	70	65	71	72	54	66.4
Secondary	21	24	25	21	20	22.2
Total forklift Injuries w/DAFW	6,820	7,710	6,820	6,750	7,490	7,118
Struck-by No. & (% of total)	1,670 (24.5%)	1,519 (19.6%)	1,150 (16.9%)	1,510 (22.4%)	1,570 (21.0%)	1,482 (20.8%)
Struck against	430 (6.3%)	510 (6.6%)	480 (7.0%)	460 (6.8%)	450 (6.0%)	466 (6.5%)
Caught in, crushed	900 (13.2%)	780 (10.1%)	760 (11.1%)	620 (9.2%)	490 (6.5%)	710 (10.0%)
Number & (Percent) of DAFW injuries when days missed are "31 or more" [d]	2,560 (37.5%)	3,280 (42.5%)	2,540 (37.2%)	2,650 (39.3%)	2,630 (35.1%)	2,732 (38.4%)

[a]Based on the Bureau of Labor Statistics (BLS), Occupational Injury and Illness Classification System 2.01, Source Code # 8621 includes "Forklift, order picker, and platform truck, powered".

[b]Source: Publicly accessible data from BLS, Census of Fatal Occupational Injuries (top part of table), and BLS, Survey of Occupational Injuries and Illnesses (bottom part of table). Both sets of data are available at: www.bls.gov/iif

[c]Primary and Secondary sources are mutually exclusive and should not be combined to obtain a yearly total.

[d]The **Number of Days Away from Work** has seven categories**: (a)** 1, **(b)** 2, **(c)** 3–5, **(d)** 6–10, **(e)** 11–20, **(f)** 21–30, and **(g)** 31 or more days. Source: "Table R 69, Number and percent distribution of nonfatal occupational injuries and illnesses including days away from work, by source of injury or illness and number of days away from work, …, private industry, (date)."