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Efficiency in reducing lost-time injuries of a nurse-based and a first-aid-based on-site medical facility

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Objectives The purpose of the study was to evaluate the efficiency of two standards for on-site medical facilities in reducing lost-time injuries during the construction of the link across the Øresund sound between Sweden and Denmark. One medical facility employed licensed nurses, who had advanced medical assistance at their disposal. The other medical facility utilized first-aid-trained watchmen. The on-site medical facilities aimed both at providing immediate medical assistance to workers subjected to occupational injuries and at reducing lost worktime.

Methods The distributions of injuries treated on-site (the worker resumed work after treatment) and injuries sent to hospitals or to specialists were compared for each type of injury and for each category of injured body part.

Results The on-site medical facilities dealt, in particular, with the treatment of ocular injuries (21%), wounds (21%), and sprains or strains (15%). The study showed a statistically significant on-site treatment (and resume work) rate ratio of 3.3 between the nurse-based (76%) and the first-aid-based (23%) medical facility.

Conclusions The construction of the Øresund Link shows a need for on-site medical facilities, particularly at remote construction sites, and that it is essential that the medical personnel have both the qualifications and authorization to treat site-specific workplace injuries effectively in order to obtain high on-site treatment rates.

Key terms comparative study; construction industry; lost worktime; occupational injuries; on-site medical treatment.

The northern part of the trans-European transport network has been under continuous development during the last two decades. By the end of 1994, the 38-kilometer channel tunnel between the United Kingdom and France had been established. The Great Belt Link, an 18-kilometer road and rail link between the two major Danish islands, Zealand and Funen, came to completion in 1998, and hereby connected east and west Denmark. The Øresund Link, a 16-kilometer road and rail link across the Øresund sound between Sweden and Denmark was completed in 2000. In addition, a 20-kilometer link across the Fehmarn Belt between Germany and Denmark is being planned.

From a health and safety perspective, the building of these major traffic links represented a great challenge, as construction is an industry with high injury incidence rates (1–2). During the construction of the Great Belt Link (3) from 1988 to 1998, it became clear that the work-related injury rate had exceeded the average injury rate of the building and construction industry in Denmark (approximately 40 injuries per million workhours [2]). During the construction of the Øresund Link from 1993 to 2000, a greater emphasis was placed on occupational health and safety (4), including two standards for on-site medical treatment facilities.

A medical facility was established offshore at the new man-made island in the Øresund sound aimed at servicing the offshore construction works. This medical facility was nurse-based due to the relatively long transportation time to the nearest hospital. The other medical facility was established at the land-based concrete element factory in Copenhagen, where prefabricated concrete tunnel elements were cast. This medical facility was only first-aid-based due to the relatively short transportation time to the nearest hospital. The primary objective of both medical facilities, as defined by

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2 According to Danish law, all injuries that result in at least 1 day's absence from work after the day of the injury must be reported to the National Working Environment Authority in Denmark.

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the site owner, was to provide immediate medical assistance and good health care to workers subjected to injury at work in order to reduce the consequences of the injuries. The secondary objective was to reduce the amount of lost worktime. These objectives reflect the principles behind many on-site medical programs, with a focus on proximity (on-site), immediacy (appropriate treatment available), and expectancy—return to normal or adapted function and reduce lost-time at work (5).

The literature on occupational safety shows that on-site medical facilities are established particularly in isolated or remote workplaces, such as offshore work platforms and the armed forces. Modern on-site facilities not only treat injuries, but also coordinate on-the-job rehabilitation (6) and are actively involved in health and safety promotion (7–8). Many studies have shown that on-site medical services are beneficial for both employers and employees (7, 9, 10).

The Øresund Link, as well as other complex (11) or remote (12) construction projects built within the last decade, has incorporated various forms of on-site medical facilities. Evaluating the effectiveness of these facilities is important, particularly as the construction of other major road and rail traffic links, like the Øresund Link, are now in the planning stages.

Therefore, the purpose of this study was to evaluate the efficiency in reducing lost-time injuries of two on-site medical facilities, one employing nurses and other employing first-aid-trained watchmen, during the construction of the Øresund Link between Sweden and Denmark.

Materials and methods

The Øresund Link project

The Øresund Link between Sweden and Denmark is comprised of the Swedish land works, the joint Swedish and Danish link across the 16-kilometer wide Øresund sound between Sweden and Denmark, and the Danish land works (13). Primarily Swedish and Danish contractors and labor forces built the link, with total project costs running at approximately EUR 2.5 billion (1990).

The coast-to-coast (east-to-west) part of the link was comprised of an 8-kilometer long, high-level bridge, including approach bridges, a 4-kilometer man-made island, and a 4-kilometer submerged tunnel. The concrete elements for the bridge were cast at a concrete element factory in Malmø, Sweden, while the concrete elements for the tunnel were cast at a concrete element factory in Copenhagen, Denmark.

Type of work

The nurse-based medical facility backed up the following offshore construction work processes in Øresund: the dredging of Øresund and the reclamation of the man-made island, the concrete work at the man-made island, the transportation and placement of prefabricated concrete tunnel elements into a trench dredged in the seabed, and the transportation and placement of prefabricated concrete caissons and piers for the bridges.

The first-aid-based medical facility at the concrete factory in Copenhagen, where the tunnel elements were prefabricated, backed up the following construction processes, reinforcement work, formwork, concrete work, outfitting (making the elements ready for leaving the factory via the dock), and jacking. The 4-kilometer submerged tunnel was comprised of 20 tunnel elements, all cast at the concrete element factory. Each tunnel element was composed of eight segments, which were reinforced and cast separately. Each segment required 250 tons of reinforcing steel, and 40–50 000 ties. Construction of the vertical wall sections was carried out by way of an elevator system, allowing the reinforcement workers to stand upright, whereas the horizontal bottom and top sections required the workers to bend over when tying the reinforcing steel rods.

Depending on their specific contract, the workers worked either alternating day and night 12-hour shifts (shifts at 0630 and 1830) or normal day work. Most of the workers lived in camps due to the great distance between their permanent address and the site. Most of the workers were thus not able to consult their own general practitioner after an injury. The workers worked in work gangs, most of which were made up of a combination of Danish and Swedish workers (the languages are very similar).

On-site medical facilities

Two on-site medical facilities were established, one at the new man-made island in the sound and one at the concrete element factory in Copenhagen, Denmark. The medical facilities were open night and day throughout the week. The medical facility on the island employed licensed nurses who had advanced medical assistance at their disposal. Telephone medical backup was given in part by a specific physician and in part by physicians at a hospital in Copenhagen. If necessary injured persons were transported to the nearest hospital either by boat and ambulance or, in special cases, by helicopter. The transportation time by boat and ambulance was between 1 and 2 hours. The medical facility at the concrete element factory in Copenhagen employed watchmen trained in first aid. In addition to first aid, the watchmen were engaged in security and alarm calls. If

needed, injured persons were transported to the nearest hospital by ambulance, which took approximately 20 minutes.

All of the injured workers were first treated on-site at the medical facilities (except for serious injuries, which were transported directly to the hospital), and each referral would lead to one of the following four treatment scenarios: (i) the worker was treated on-site at the medical facility and immediately resumed work, (ii) the worker received preliminary treatment at the medical facility and was subsequently sent to a hospital's casualty department, (iii) the worker received preliminary treatment at the medical facility and was subsequently sent to a specialist (including own general practitioner or dentist), and (iv) the worker received preliminary treatment at the medical facility and was subsequently sent to the camp for rest.

The first scenario, in which the injured worker resumed work after treatment, implies no sick leave due to injury. The next three scenarios, in which the worker is sent to a hospital and so forth, implies time lost on the day of the injury and sometimes even absence [3] (starting the next day).

Registration of injuries and medical reports

Both medical facilities were to register all of the injury incidents, regardless of the treatment scenario. They were also registered if the injured person was transported directly to the hospital without first visiting the medical facility. The following information was recorded after an incidence: personal information, type of work, type of injury incident, type of injury, injured body part, what had happened, where the incident had happened, and what actions were taken. The registration of injured body part(s) and type(s) of injury was made in accordance with the National Danish Injury Registration System, developed by the National Working Environment Authority in Denmark (14). Injured body parts and types of injury were divided into 16 categories each. A casualty department standard medical journal was prepared at the hospital, and, if transportation had taken place with an ambulance, an ambulance journal was written up. Copies of these journals were handed over to the site owner. A fraction of the injured workers was sent to specialists for further treatment; however, records from these visits were not collected. In the year 2000, the site owner handed over the injury reports to the National Institute of Occupational Health in Denmark. These data formed the basis for the present study.

Study group and period

The nurse-based medical facility was in operation from 1 January 1997 to 31 March 1999, and the study period covered the whole operation period. This facility was servicing offshore works. The number of workyears for this part of the project was unknown, but it has been estimated to be on the order of 2500 workyears. The first-aid-based medical facility was in operation from 1 January 1997 to 31 March 1998, and the whole operation period was covered. The number of workyears was approximately 800 years during the study period.

The medical facilities serviced all of the employees involved in the project. Approximately 90% of the employees were hourly paid construction workers; the rest comprised managers and administrative personnel.

Analysis

The efficiency in reducing lost-time injuries of the on-site nurse-based and first-aid-based medical support for the construction workers was evaluated by analyzing the distributions of injuries treated onsite (the worker resumed work), injuries sent to a hospital (injuries transported directly to the hospital without the worker first visiting the medical facility), and injuries sent to a specialist or to the camp. The distributions were calculated for each type of injury and each category of injured body part.

Mantel-Haenszel statistics were used to estimate the rate ratio for the onsite treatment between the two standards of medical facility, after control for injured body part and type of injury. All of the statistical analyses were performed using the Stata Statistical Package, Version 7.0 (College Station, TX, USA) and the SAS Statistical Package, Version 8.2 (SAS Institute Inc, NC, USA).

Results

Nurse-based on-site medical facility

During the study period, the on-site nurse-based medical facility treated a total of 497 injuries, 464 (93%) of which were occupationally related and the remaining 7% having occurred during the workers' free time. A total of 34% of all the injuries were treated with medicine, mainly analgesics. Telephone medical backup to physicians was used for 3% of all the injuries. In addition to the 497 injuries, the medical facility had 82 injury follow-ups.

3 According to Danish law, absence from work due to injuries starts the day after the injury. Lost workhours on the day of the injury incident is not included in the absence.

Altogether 76% of the occupational injuries were treated onsite at the nurse-based medical facility, whereupon the workers resumed work, 16% were sent to a hospital's casualty department, 2% were sent to specialists, and the remaining 6% were sent to the camp for rest (table 1). Neck (90%) and eyes (84%) had the highest on-site treatment percentages, while the feet and ankles (primarily sprains or strains) had the lowest on-site treatment percentage (46%).

The most frequently injured body parts were the eyes (21%) (primarily caused by a foreign object in the eye and secondarily by welding light) and the fingers (17%) (primarily wounds). The most common types of injuries (table 2) were wounds (22%) and sprains or strains (12%).

First-aid-based on-site medical facility

The first-aid-based on-site medical facility registered a total of 229 injuries. All of the injuries were occupational in nature, as none of the injuries occured at home or in the camp. There was no follow-up at the medical facility after the injury, and medicine was not supplied at the medical facility.

Altogether 23% of the injuries were treated on site at the first-aid-based medical facility, after which the workers resumed work. Altogether 68% were sent to a hospital's casualty department, 8% were sent to specialists, and the remaining 2% of the injured workers were sent to their camp for rest. Hands (41%) and legs (35%) had the highest on-site treatment percentages, while back or spine injuries had one of the lowest on-site treatment percentages (14%), and 38% of these injuries were sent to a specialist.

The most frequently injured body parts were the eyes (21%) (primarily caused by a foreign object in the eye and secondarily by welding light) and the feet and ankles (14%) (primarily sprains or strains). The most common types of injuries were wounds (21%) and sprains or strains (21%).

Comparison of a nurse-based with a first-aid-based on-site medical facility

The proportion of injuries treated on site (worker resumed work) at the nurse-based medical facility was 76%, whereas it was only 23% at the first-aid-based medical facility. After control for the type of injury and injured body part, the Mantel-Haenszel estimate for the rate ratio for on-site treatment was 3.3 (95% CI 2.3–4.3). There were, however, considerable differences in the rate ratio for the on-site treatment depending on the injured body part and the type of injury (tables 1 and 2), but the differences were not statistically significant.

Effect of the medical facilities on the reduction of lost-time injuries

The effect on lost-time injuries was primarily determined by the following two factors: (i) the elimination of transportation to and from the hospital or specialist on the day of the injury, including waiting time, for the proportion of injured workers treated on site (and resumed work) and (ii) a speedier return to work as a result of early, provisionally on-site treatment of all injuries. The first factor can be roughly estimated for the nurse-based medical facility by using the following assumptions: for the 352 injured workers treated on site (and resumed work) an estimated loss of 6 workhours (one-half of a workday) was avoided due to the elimination of transportation and the like to a hospital or

Table 1. Efficiency of a nurse-based and a first-aid-based on-site medical facility during construction of the Øresund Link—injured body part.

Injured body part	Nurse-based facility injuries (%)					First-aid-based facility injuries (%)					On-site treatment rate ratio nurse-based/ first-aid-based
	Number (N=464)	On-site [a] treatment	Sent to hospitals	Sent to specialists	Sent to the camp	Number (N=229)	On-site [a] treatment	Sent to hospitals	Sent to specialists	Sent to the camp	
Head	5.0	74	17	9	0	8.7	25	75	0	0	3.0
Eyes	20.9	84	7	2	7	21.0	23	73	4	0	3.6
Neck	4.3	90	5	5	0	1.3	0	67	33	0	–
Back, spine	11.6	80	2	4	15	9.2	14	38	38	10	5.6
Arm	10.6	82	12	2	4	10.5	17	79	4	0	4.9
Hand	4.5	67	33	0	0	7.4	41	59	0	0	1.6
Finger	16.6	75	23	0	1	7.0	13	88	0	0	6.0
Leg	11.6	72	24	0	4	10.0	35	57	4	4	2.1
Foot, ankle	7.5	46	34	3	17	14.0	22	69	6	3	2.1
Other parts	7.3	76	21	3	0	10.9	20	68	12	0	3.8
All parts	100	76	16	2	6	100	23	68	8	2	3.3 [b]

[a] The worker immediately resumed work after on-site treatment.
[b] Mantel-Haenszel estimate for the on-site treatment rate ratio, controlling for body part. Test for treatment rate ratio effect modification by body part was not statistically significant.

Table 2. Efficiency of a nurse-based and a first-aid-based on-site medical facility during the construction of the Øresund Link – type of injury.

Type of injury	Distribution of injuries (%)		On-site treatment rate [a] (%)		On-site treatment rate ratio (nurse-based/ first-aid-based)
	Nurse-based medical facility (N=464)	First-aid-based medical facility (N=229)	Nurse-based medical facility	First-aid-based medical facility	
Bruises	9.7	16.6	67	24	2.8
Wounds	22.4	20.5	73	26	2.9
Fractures	1.7	1.3	0	0	-
Sprains or strains	12.3	20.5	61	19	3.2
Thermal (hot or cold)	5.2	2.2	88	60	1.5
Foreign body in the eye	20.3	19.2	83	25	3.3
Other injuries	28.4	19.7	85	18	4.8
All types of injuries	100	100	76	23	3.3 [b]

[a] The worker immediately resumed work after on-site treatment.
[b] Mantel-Haenszel estimate for the on-site treatment rate ratio, controlling for injury type. Test for treatment rate ratio effect modification by type of injury was not statistically significant.

specialist; the total absence (starting the day after the injury) due to injuries during the study period was approximately 15 600 lost workhours and thus the avoided loss of workhours on the day of the injury due to the elimination of transportation and the like in the percentage of the total absence was approximately 14%. However if we assume that only workers who could not have been treated at the first-aid-based medical facility would have been sent to the hospital (in the lack of a nurse-based medical facility), then the 14% would be reduced to 9% [14% × (3.3–1)/3.3] (3.3 is the treatment rate ratio between the nurse-based and the first-aid-based medical facility).

The second factor, a speedier return to work as a result of early, provisionally on-site treatment of injuries, may very well be the most important factor. We have, however, no data with which to make any estimate for confirming this possibility.

Discussion

Two standards of medical facilities were established during the construction of the Øresund Link between Sweden and Denmark. One employed licensed nurses, the other first-aid trained watchmen. The study showed a statistically significant on-site treatment rate ratio of 3.3 between the nurse-based and first-aid-based medical facility; 76% and 23% of the injured workers, respectively, immediately resumed work after treatment. Previous studies have looked at the effect of first-aid on-site treatment (15–16). The treatment result of the nurse-based medical facility in our study is similar to the result of a doctor-based medical facility at a Spanish tunnel construction project (11), where 87% of the injured workers were treated on-site and immediately resumed work.

The medical facilities for the Øresund Link project covered a need for on-site medical treatment of, in particular, ocular injuries, wounds, and sprains or strains. Ocular injuries resulted primarily from receiving a foreign object in the eye and secondarily from welding light during the reinforcement and concrete work processes. According to the medical reports, many of these injuries could have been avoided if proper eye protection had been used. Most of the wounds resulted from wires puncturing fingers during the tying of reinforcement steel. Most of the sprain or strain injuries (feet or ankles and back or spine) resulted from either awkward work positions (tying of the reinforcement steel was often done in a stooping position) or heavy lifts during formwork (17–18). Sprain or strain injuries in particular had a relatively low on-site treatment percentage at both medical facilities.

The avoided loss of workhours on the day of the injury due to the nurse-based medical facility in the percentage of the total absence (starting the day after the injury) due to injuries was in the range of 9–14%. The effect on the total number of lost workhours would probably be higher if the effect of speedier return to work was included, but, on the other hand, the on-site medical facility might have led to an increased demand for medical attention—the overutilization hypothesis (19).

We have evaluated possible misdiagnosis or incorrect treatment of occupational injuries at the nurse-based facility. Only one of the patients, of those who were not sent to a hospital, had a long treatment period with several follow-up visits. A physician has evaluated this case and found that the initial treatment by the nurse was sufficient, but the compliance of the patient to the treatment was poor. In general, we concluded that the treatments at the nurse-based medical facility were sufficient. Furthermore, we were able to see that some workers returned for follow-up treatment at the nurse-based facility after being referred to a physician and thus prevented further absence from work.

In conclusion, the services of on-site medical facilities can be mutually beneficial for workers and employers, resulting in immediate medical support, good health care, and reduced loss of workhours on the day of an injury, probably also a speedier return to work. In terms of numbers and incidence rates, the construction of the Øresund Link shows a need for on-site medical facilities, especially at remote construction sites. In particular, the need for on-site medical specialization in treating ocular injuries, strains, sprains, and wounds is great. Our study indicates that more focus on the prevention and on-site treatment of these types of injuries would

reduce the number of injuries and lost worktime significantly. It also shows that it is essential that medical personnel have both the qualifications and authorization to effectively treat site-specific workplace injuries in order to obtain high on-site treatment rates.

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