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Long-term follow-up of trauma patients before and after implementation of a physician-staffed helicopter: A prospective observational study

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ABSTRACT

Introduction: The first Danish Helicopter Emergency Medical Service (HEMS) was introduced May 1st 2010. The implementation was associated with lower 30-day mortality in severely injured patients. The aim of this study was to assess the long-term effects of HEMS on labour market affiliation and mortality of trauma patients.

Methods: Prospective, observational study with a maximum follow-up time of 4.5 years. Trauma patients from a 5-month period prior to the implementation of HEMS (pre-HEMS) were compared with patients from the first 12 months after implementation (post-HEMS). All analyses were adjusted for sex, age and Injury Severity Score.

Results: Of the total 1994 patients, 1790 were eligible for mortality analyses and 1172 ($n = 297$ pre-HEMS and $n = 875$ post-HEMS) for labour market analyses. Incidence rates of involuntary early retirement or death were 2.40 per 100 person-years pre-HEMS and 2.00 post-HEMS; corresponding to a hazard ratio (HR) of 0.72 (95% confidence interval (CI) 0.44–1.17; $p = 0.18$). The HR of involuntary early retirement was 0.79 (95% CI 0.44–1.43; $p = 0.43$). The prevalence of reduced work ability after three years were 21.4% vs. 17.7%, odds ratio (OR) = 0.78 (CI 0.53–1.14; $p = 0.20$). The proportions of patients on social transfer payments at least half the time during the three-year period were 30.5% vs. 23.4%, OR = 0.68 (CI 0.49–0.96; $p = 0.03$). HR for mortality was 0.92 (CI 0.62–1.35; $p = 0.66$).

Conclusions: The implementation of HEMS was associated with a significant reduction in time on social transfer payments. No significant differences were found in involuntary early retirement rate, long-term mortality, or work ability.

Introduction

Trauma is a leading cause of death in young adults [1]. This has resulted in a demand for higher quality of emergency preparedness, and time-efficient transportation of severely injured patients has attracted growing public interest. Many countries have implemented helicopter-based systems to strengthen the emergency response, and the potential benefits have been studied several times [2,3]. Time gain and short-term mortality (up to 30 days) are the outcome variables most often applied in studies evaluating helicopter services against ground services [4–9].

In May 2010, the first physician-staffed Helicopter Emergency Medical Service (HEMS) was implemented in the eastern part of Denmark. The implementation was associated with improved short-term outcomes, such as reduced time to specialised care, fewer secondary transfers and lower 30-day mortality for severely injured trauma patients [10].

Mortality is a very crude outcome measure and it does not provide information on disabilities affecting work ability or dependency on social transfer payments. Initiatives to lower short-term mortality after trauma may be at the expense of a worse functional outcome. Hence, trauma may have negative impact on long-term employment or lead to involuntary early retirement, and persons who leave the workforce due to health problems may be more likely to become impoverished than those who retire in good health [11–13].

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The aim of the present study was to assess the long-term effects of the implementation of HEMS on labour market affiliation measured as involuntary early retirement, work ability, need for social transfer payments, and long-term mortality up to 4.5 years after the trauma.

The study was approved by The Danish Data Protection Agency (file number: 2013-41-1973 and 2013-231-0042) and by the National Board of Health (file number: 3-3013-352/1/HKR). Approval from the Ethics Committee as well as patient consent is not required for studies based on registries, according to Danish law.

Material and methods

Study design and setting

This was a prospective, observational study with long-term follow-up of the same cohort as in the initial study of the first Danish HEMS [10]. Eight trauma centres provided data, including one level 1 and seven level 3 or 4 eq. trauma centres. Before May 1st, 2010, the regional EMS consisted of a two-pronged ground unit system (1) An ambulance staffed with either basic life support providers or paramedics, and (2) A mobile emergency care unit staffed with consultants in anaesthesiology or anaesthetic nurses. In case of suspected severe trauma, the dispatch centre would dispatch both units simultaneously, with rendezvous at the site of the incident. Patients would either be brought to the nearest hospital or directly to the level 1 trauma centre at the discretion of a physician. On May 1st 2010, a physician-staffed HEMS was introduced to supplement the existing system. The HEMS operated during daytime only, covering a catchment area of 8400 km^2. HEMS was dispatched in case of suspected severe trauma, and when the expected driving distance from scene of incident to the level 1 trauma centre exceeded 30 min. HEMS was typically dispatched together with an ambulance unit, and occasionally together with both ambulance and MECU unit.

Selection of participants

All trauma patients treated in HEMS' catchment area in a 17-month period from December 1st 2009 to April 30th 2011, and who triggered trauma team activation in one of the eight trauma centres, were included. Follow-up period was until May 1st 2014. We excluded patients who upon arrival at the hospital were re-categorised as non-trauma patients, and patients who arrived by private transport or were brought in by the police.

Intervention

A 5-month period (December 1st 2009 to April 30th 2010) immediately before implementation of HEMS (pre-HEMS) was compared with the first 12 months (May 1st 2010 to April 30th 2011) after HEMS implementation (post-HEMS). Follow-up period was until May 1st 2014.

Data sources

Trauma records

Data were retrieved from trauma registration sheets as previously reported [10].

Danish civil registration system (DCRS)

The DCRS [14] is administered by the Danish government, which since 1968 has assigned a unique civil registration number (CPR number) to all persons who take up residence in Denmark including foreign nationals. The registry includes vital statistics and demographic information, and is updated within days.

DREAM

Current employment status in Denmark was analysed using the Ministry of Employment's Danish Register for Evaluation of Marginalization (DREAM) database, which contains information on all social transfer payments such as sickness benefits, unemployment benefits, social assistance, and pensions (disability and old-age pension, public and private). The database includes all persons who have received social transfer payments from any Danish authority since 1991.

The DREAM database is administered by the Danish Agency for Labor Market and Recruitment (under the Ministry of Employment) and is updated weekly with a latency period of 3 months. A weekly code is assigned to each person, based on the kind of income (work salary or any type of social transfer payments). The codes are ranked internally and just a single day on any subsidy will trigger a weekly allowance code for not being employed full-time.

To meet the requirements for involuntary early retirement, citizens should be between age 18 and 64 years and have at least a 50% permanently reduced work capacity, preventing them from providing for themselves through profitable employment. Involuntary early retirement is independent of private insurance status and awarded for life. The application process may take from a few months up to two years.

Data extraction

From trauma records, we retrieved data on: specific injuries, injury severity score (ISS), mode of transportation, time intervals and demographics. From DREAM, we retrieved data on: labour market affiliation. From DCRS, we retrieved data on sex and dates of death or emigration. Data were linked through the CPR number.

Outcome measures

The primary endpoint was a combined outcome of time to involuntary early retirement (disability pension) or death of any cause after trauma.

Secondary endpoints were time to involuntary early retirement, time to death from any cause, prevalence of reduced work ability three years after trauma, and percentage of time on social transfer payments during the first three years after trauma.

Statistical analysis

Continuous variables are reported as medians and interquartile range (IQR) and compared between subgroups in the data using Mann–Whitney's *U* test. Categorical data are reported as numbers (%) and compared between subgroups in the data using a Chi-squared test. We consider p-values <0.05 as statistically significant. SAS 9.3 statistics (SAS Institute Inc., Cary NC 27513-2414, USA) was used for statistical analyses.

Survival analyses were conducted for the primary "combined outcome" and the two secondary outcomes of "involuntary early retirement" and "death from any cause. Incidence rates (IR) pre-HEMS and post-HEMS were calculated and illustrated in Kaplan-Meier plots. The relative difference in incidence between the two groups was analysed in Cox proportional hazards regression models, unadjusted as well as adjusted for sex, age, and ISS. Since no involuntary early retirement occurred in the 30 days directly following the trauma, statistics pertaining these first 30 days after trauma were not calculated for the secondary outcome "involuntary early retirement".

The secondary outcome of "prevalence of reduced work ability three years after trauma" was assessed in logistic regression models with adjustment for sex, age and ISS. Patients were

dichotomised as trauma patients with 100% maintained work ability after three years or not. Work ability is considered to be a fluctuating, temporary condition contrary to involuntary early retirement which reflects degree of permanent disability.

The secondary outcome of "percentage of time on social transfer payments" was dichotomised as the proportion of trauma patients who were on social transfer payments more than 50% of the time during the first three years after trauma. This outcome was assessed in logistic regression models adjusted for sex, age and ISS.

All analyses, except "death from any cause" in which all subjects were included, were performed on patients between 18 and 60 years of age to ensure a sample that was at risk of involuntary early retirement during the full follow-up period (i.e. were not eligible for voluntary early retirement). Subjects who had had an event before the time of trauma (were retired or were on social transfer payments) were not included in the corresponding analyses.

Sensitivity analysis

Since HEMS only operated during daytime, additional analyses were performed separately for daytime (08:00–20:00 hours), and night-time trauma, in an attempt to separate the effect of HEMS implementation from general improvements in the EMS system during the course of the study.

Severely injured patients may be more likely to suffer permanent disabilities after trauma, thus postpone return to work or even lead to involuntary early retirement; we therefore did a supplemental analysis on the sub-group of patients with ISS >15.

Trial registration

The study was registered at ClinicalTrials.gov (NCT02175862) before data analysis.

Results

Characteristics of study subjects

1994 patients triggered trauma team activation, of which 1790 patients were eligible for inclusion in the study (Fig. 1) and eligible for the secondary outcome analysis "time to death from any cause". Of these, 1271 patients were between 18 and 60 years of age, 99 of which were retired before trauma: 7.2% ($n = 22$) pre-HEMS and 8.5% ($n = 77$) post-HEMS. Hence, 1172 patients were eligible for the primary outcome and secondary outcome labour market analyses. Patients were comparable in relation to sex, age, and ISS (Table 1).

Main results

The IR of involuntary early retirement or death were 2.40 per 100 person-years at risk (PYR) pre-HEMS and 2.00 per 100 PYR post-HEMS (Fig. 2), adjusted hazard ratio (HR) = 0.72 (95% CI 0.44–1.17, $p = 0.18$) (Table 2).

The IR of involuntary early retirement in survivors after the first 30-days was 1.60 per 100 PYR pre-HEMS and 1.39 per 100 PYR post-HEMS, adjusted HR = 0.79 (CI 0.44–1.43; $p = 0.43$) (Table 2).

All-cause mortality for all ages was 2.25 per 100 person-years pre-HEMS and 1.94 per 100 person-years post-HEMS (Fig. 3), corresponding to a hazard ratio of 0.74 (CI 0.51–1.10; $p = 0.14$), adjusted HR = 0.92 (CI 0.62–1.35; $p = 0.66$) (Table 2).

Our analysis of reduced work ability after trauma was limited to those 80% of patients aged 18–60 years who were at full work ability before the trauma: 243 patients pre-HEMS and 694 patients post-HEMS. The prevalence of reduced work ability at three years after trauma was 21.4% pre-HEMS and 17.7% post-HEMS, odds ratio (OR) = 0.78 (CI 0.53–1.14; $p = 0.20$) (Table 3).

The percentage of time (median) on social transfer payments during the first three years after trauma was 14.9% (IQR 1.3–67.3) pre-HEMS and 11.5% (IQR 0.0–48.7) post-HEMS, with an adjusted OR of receiving social transfer payments for more than half the time of 0.68 (95% CI 0.49–0.96; $p = 0.03$) in patients who were at full work ability before trauma (Table 3). Adjusted OR during daytime was 0.68 (CI 0.46–1.00; $p = 0.05$) and 0.71 (0.36–1.41; $p = 0.33$) during night-time.

IR of involuntary early retirement or death in the group of severely injured patients (ISS > 15) was 13.66 per 100 PYR pre-HEMS and 11.77 per 100 PYR post-HEMS, adjusted HR = 0.65 (CI 0.30–1.42; $p = 0.28$).

Table 1
Patient characteristics (age 18–60 years). HEMS: helicopter emergency medical system; IQR: interquartile range; ISS: injury severity score; NISS: new injury severity score.

	Pre-HEMS ($n = 297$)	Post-HEMS ($n = 875$)	Total ($n = 1172$)	Missing	p-Value
Sex, *n* (%)				0	0.9933
Woman	107 (36.0)	315 (36.0)	422 (36.0)		
Man	190 (64.0)	560 (64.0)	750 (64.0)		
Age, median (IQR)	35 (24–46)	34 (22–45)	34 (23–46)	0	0.1048
ISS, median (IQR)	1 (0–5)	1 (0–5)	1 (0–5)	1	0.2383
NISS, median (IQR)	2 (0–8)	2 (0–8)	2 (0–8)	2	0.4687
Transport, *n* (%)				15	<0.0001
Physician staffed helicopter	0 (0.0)	117 (13.6)	117 (10.1)		
Mobile emergency care unit (physician)	102 (34.6)	222 (25.8)	324 (28.0)		
Ambulance	179 (60.7)	501 (58.1)	680 (58.8)		
Other emergency car (nurse, paramedic)	14 (4.8)	22 (2.6)	36 (3.1)		
Time, *n* (%)				0	0.1877
Daytime (7:00–21:00)	231 (77.8)	647 (73.9)	878 (74.9)		
Nighttime (21:00–7:00)	66 (22.2)	228 (26.1)	228 (26.1)		
Work, *n* (%)				106	0.8555
Blue collar	50 (19.5)	167 (20.6)	217 (20.4)		
Pink collar	59 (23.1)	177 (21.9)	236 (22.1)		
White collar	38 (14.8)	135 (16.7)	173 (16.2)		
Not recorded	109 (42.6)	331 (40.9)	440 (41.3)		
Severe head trauma (Head AIS > 3), *n* (%)				0	0.6837
No	288 (97.0)	852 (97.4)	1140 (97.3)		
Yes	9 (3.0)	23 (2.6)	32 (2.7)		

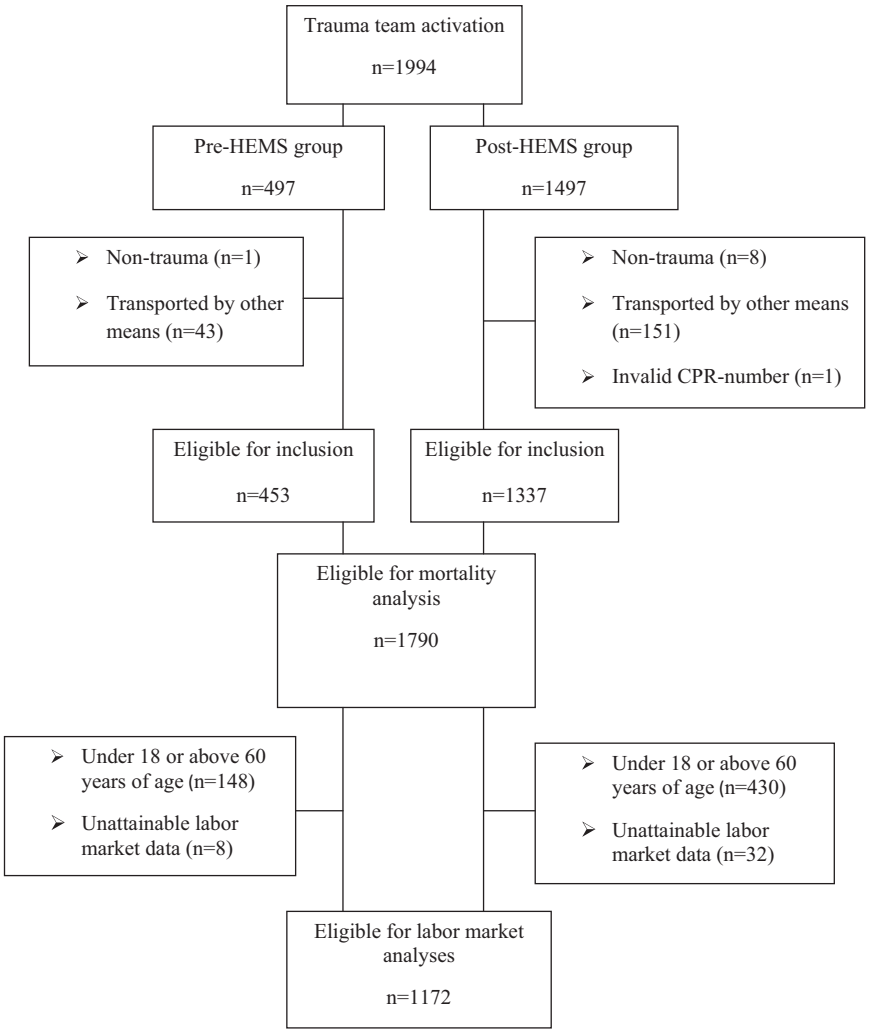

Fig. 1. Flowchart of included patients.

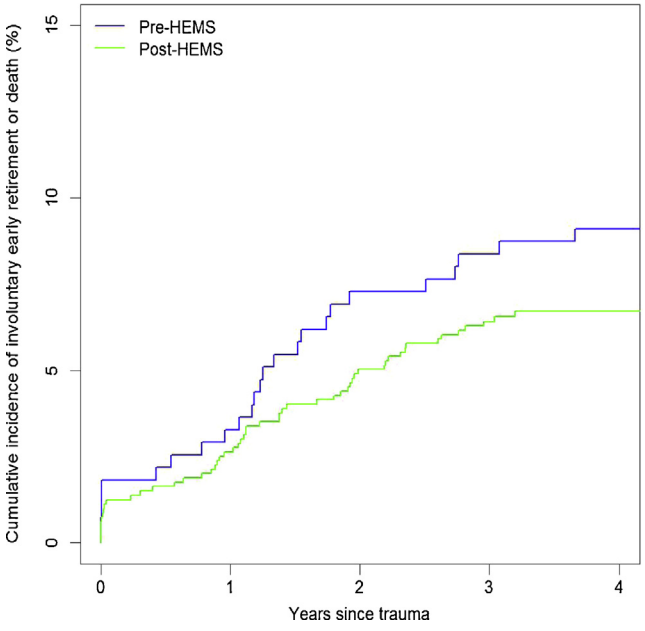

Fig. 2. Time to involuntary early retirement or death.

Discussion

We found a 28% reduction in involuntary early retirement or death in trauma patients after implementation of the HEMS, a 21% reduction in involuntary early retirement, a 22% reduction in reduced work ability, and a 32% reduction in the risk of receiving social transfer payments for more than half the time after trauma. Only the latter was significant at the 5% level, but all point in the same direction.

Main strengths of our study were the study size, the low proportion of subjects lost to follow-up (less than 5%), and the well-defined geographical area, minimizing the risk of selection bias and providing high internal validity. The 3–4.5 years of follow-up time allowed us to asses long-term physical outcome and labour market status, since ongoing improvements of recovery may be seen even three to five years after injury [15]. The DREAM database provided reliable and almost complete data on labour market affiliation, minimizing the risk of information bias often seen when these data are self-reported [16,17].

The involuntary early retirement scheme was altered in January 2013, leading to a discontinuation of involuntary early retirement for patients under the age of 40 years. The median age was 34 years in our study population and some patients may have been in the process toward receiving involuntary early retirement, but this option could be lost due to the changes in legislation. This may

Table 2
Incidence of involuntary early retirement or death, and reduced work ability three years after trauma. HR: hazard ratio; OR: odds ratio; IR: incidence rate; PYR: person-years at risk; HEMS: helicopter emergency medical service; ISS: injury severity score.

	Number of persons under observation in each group (pre-HEMS/ post-HEMS)	Number of events	Total PYR	Pre-HEMS IR (per 100 PYR)	Post-HEMS IR (per 100 PYR)	Unadjusted HR (95%CI)[2]	*p*-Value	Adjusted[1] HR (95%CI)[2]	*p*-Value
Involuntary early retirement or death ($n=1172$)	275/798								
First 30 days		5/10	22/65	22.53 (2.78–42.28)	15.43 (5.86–24.99)	0.69 (0.24–2.01)	0.49	0.58 (0.19–1.74)	0.33
After the first 30 days		21/43	1063/2587	1.98 (1.13–2.82)	1.66 (1.17–2.16)	0.75 (0.44–1.28)	0.30	0.76 (0.44–1.29)	0.30
The entire follow-up period		26/53	1085/2652	2.40 (1.48–3.32)	2.00 (1.46–2.54)	0.74 (0.46–1.19)	0.21	0.72 (0.44–1.17)	0.18
Involuntary early retirement ($n=1172$)	275/798								
After the f irst 30 days		17/36	1063/2587	1.60 (0.84–2.36)	1.39 (0.94–1.85)	0.77 (0.43–1.40)	0.39	0.79 (0.44–1.43)	0.43
All-cause death ($n=1790$)	445/1294								
First 30 days		19/34	35/104	54.10 (29.77–78.42)	32.73 (21.73–43.73)	0.61 (0.35–1.07)	0.08	0.76 (0.43–1.36)	0.35
After the first 30 days		20/49	1698/4185	1.18 (0.66–1.69)	1.17 (0.84–1.50)	0.89 (0.53–1.49)	0.65	1.06 (0.63–1.79)	0.83
The entire follow-up period		39/83	1733/4289	2.25 (1.54–2.96)	1.94 (1.52–2.35)	0.74 (0.51–1.10)	0.14	0.92 (0.62–1.35)	0.66

[1] Adjusted for sex, age (quadratic) and ISS (quadratic), assuming equal effect for these variables for the first month and for the rest of the follow-up.
[2] The effect of the post-HEMS period compared to the pre-HEMS period.

cause an underestimation of involuntary early retirement. However, the process of determining patients eligible for involuntary early retirement usually takes 2–3 years, so this would result in fewer events late in the follow-up, as can be suspected in Fig. 2, but it seems unlikely to cause major differences between the two periods.

Structural changes others than the HEMS implementation may have driven our findings, and the similar effect sizes observed for daytime and night-time trauma support this assumption. Increased focus on pre-hospital care both among professionals and the general population, partly driven by the excitement of implementation of the first HEMS in Denmark, accompanied by continuous training of pre-hospital staff, may have contributed to the improved outcomes.

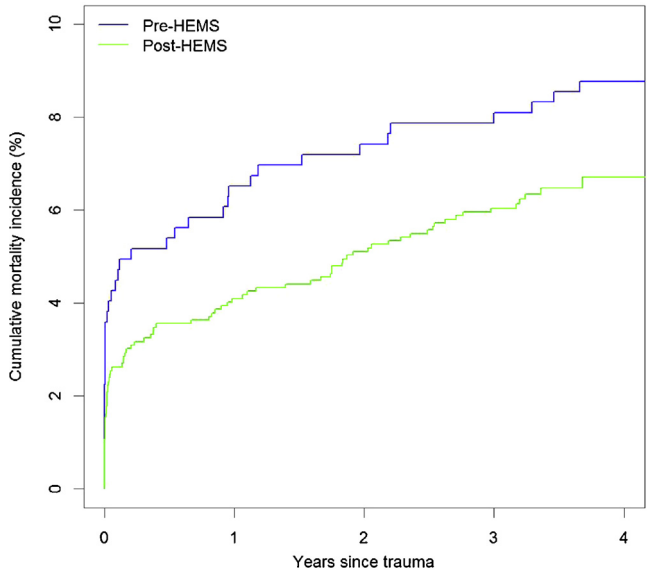

Fig. 3. Cumulative risk of death.

Two months before completion of the inclusion period, the physician-staffed Mobile Emergency Care Unit was discontinued in a part of the HEMS catchment area, leaving just the paramedic-staffed primary ambulances to operate in the area besides HEMS. However, the impact of this change would only tend to diminish the observed difference in outcome between the two periods.

Strict labour market retention policies on continuous adaptability may force patients to explore every possible option of reassignment to other work tasks, hence delaying the process of receiving involuntary early retirement. In addition, patients with permanent injuries causing less than 50% reduced work capacity will not be entitled for involuntary early retirement either. However, we have no reason to expect that this would influence the two periods differently, and the relative risk should be unaffected.

Previous studies have associated HEMS with better survival [18,19]. However, the beneficial impact of HEMS was suggested to only concern specific sub-groups [4,20]. This can lead to biased estimates for the overall trauma population. The study on the Danish HEMS implementation [10] showed a significant reduction in 30-day mortality in the group of severely injured trauma patients with ISS >15, which supports the previous findings by Mitchell et al. [21]. It is debated whether interventions improving the survival of severely injured patients occurs at the expense of a worse functional outcome due to e.g. severe brain injury or physical disablement [22]. In the current study, we found a 35%

Table 3
Work ability after three years and time on social transfer payments during the first three years. HEMS: helicopter emergency medical service; IQR: interquartile range; OR: odds ratio; ISS: injury severity score.

	Number of persons under observation in each group (pre-HEMS/ post-HEMS)	Pre-HEMS *n* (%)	Post-HEMS *n* (%)	Unadjusted OR (95%CI)[2]	*p*-Value	Adjusted[1] OR (95%CI)[2]	*p*-Value
Prevalence of reduced work ability three years after trauma ($n=1172$)	243/694	52 (21.4)	123 (17.7)	0.79 (0.55–1.14)	0.21	0.78 (0.53–1.14)	0.20
Time on social transfer payments (full work ability) ($n=1172$)							
Over 50% of time on social transfer payments during the first three years after trauma	243/693	74 (30.5)	162 (23.4)	0.70 (0.50–0.96)	0.03	0.68 (0.49–0.96)	0.03
Daytime							
Over 50% of time on social transfer payments during the first three years after trauma	188/523	55 (29.3)	117 (22.4)	0.70 (0.48–1.01)	0.06	0.68 (0.46–1.00)	0.05
Nighttime							
Over 50% of time on social transfer payments during the first three years after trauma	55/170	19 (34.6)	45 (26.5)	0.68 (0.36–1.31)	0.25	0.71 (0.36–1.41)	0.33

[1] Adjusted for sex, age (quadratic) and ISS (quadratic).
[2] The effect of the after HEMS period compared to the before HEMS period.

(insignificant) reduction in involuntary early retirement or death in patients with ISS >15, but the low number of observations does not allow a firm conclusion. We found no trade-off between survival and work ability.

Return to work can be a measurement of physical function and has been found to be an appropriate outcome measure for that purpose [23]. Thus, severely injured patients had more than a doubled risk of early retirement compared to the less injured in one study [24], and similar results have showed that the impact of severe physical injury can have profound influence on the return to work after trauma [12,13,25,26].

In general, return to work is dependent of Socio Economic Status (SES) [27], and occupational position at the time of trauma is a strong predictor for returning to work [25]. Disparities in SES can be stratified by level of education [28] or type of work (e.g. blue, white collar work, etc.) [29] and low level of education is independently associated with disability pension [28]. Unskilled workers (e.g. blue collar workers) often have physically demanding jobs and since patients with low level of education may be less flexible and have fewer options in choosing profession or reassignment at the work place, they may be at greater risk of permanent withdrawal from the workforce. We did not have access to information on level of education, but instead we gathered information on type of work. Regrettably, there is large inconsistency in the reporting of line of work (including shift in status) for each patient from the local municipality to the DREAM database and as a result we only had information on 59% of patients (Table 1). Therefore we did not include this in the adjusted analysis and there is no reason to expect a difference in type of work between the two time periods.

Employees who have joined an unemployment insurance fund and paid contributions for at least 30 years may be eligible for voluntary early retirement. This is a transitional scheme between working life and retirement that offers the possibility of early withdrawal from the labour market from the age of 60 years, instead of at the standard retirement age of 65 years. The scheme is aimed at employees who are unable to continue working beyond the age of 60 years because they have spent years working in physically demanding jobs. Because we only had few events of voluntary early retirement an analysis of this aspect was not justified.

The reduced risk of involuntary early retirement or death found in our primary analysis did not reach statistical significance. This may be related to low statistical power associated with a low number of events. For patients not entitled to voluntary early retirement (especially self-employed patients), financial incentives may also influence the number of events as the decision to retire early is highly affected by the patient's economical situation [26].

The reduction in percentage of time on social transfer payments during the first three years post-HEMS indicated that the increased number of patients who survive trauma, actually do better in the long haul as well. Therefore, it seems that the increased short term survival after HEMS implementation was not associated with an increased burden of social subsidy, but rather resulted in less time on social transfer payments and an increased work force. We found a significant difference in time on social transfer payments only in daytime patients, indicating a positive influence of HEMS, but when considering the few events at night and almost identical OR (0.68 vs. 0.71) interpretation of the reduced risk might very well be attributed to the overall system-change following the implementation of HEMS, rather than the HEMS itself. The combination of increased primary triage, reduced time to highly specialised care, and better trauma care when more patients were treated at a level 1 trauma centre, might explain an improved functional outcome.

Conclusions

The implementation of a physician-staffed helicopter was associated with a significant reduction in time on social transfer payments. Reductions of similar magnitude, although not statistically significant, were found in involuntary early retirement rate, work ability, and long-term mortality.

Conflict of interest statement

KSF, LSR and RH have received support from the The Tryg Foundation for the submitted work; JS's institution has received

research grants from The Tryg Foundation. VS and NL have no relationships with any organisation that might have an interest in the submitted work in the previous 3 years. All authors declare no other relationships or activities that could appear to have influenced the submitted work.

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