

SUPPLEMENTARY APPENDIX**Supplement 1. Presenting problems****Supplement 2. Immediate Life-saving Interventions****Supplement 3. Missing data for vital signs****Supplement 4. Complete case analyses****Supplement 5. Hospital characteristics****Supplement 6. Stratified regression analyses**

Supplement 1. Presenting problems

Supplementary table 1.1 Presenting problems definitions	
Subgroups ^a	MTS Flowchart
General malaise	Crying baby. Unwell child. Worried parent. Irritable child. Unwell adult.
Trauma or muscular	Assault. Falls. Head injury. Limb problems. Major trauma. Torso injury. Neck pain. Back pain. Limping child.
Gastro-intestinal	Abdominal pain in adults. Abdominal pain in children. Diarrhoea and vomiting. GI Bleeding.
Respiratory	Asthma. Shortness of breath in adults. Shortness of breath in children.
Ear, Nose, Throat	Ear problems. Sore throat. Facial problems.
Neurologic or Psychiatric	Behaving strangely. Fits. Headache. Apparently drunk. Collapsed adult. Overdose and poisoning. Self-harm. Mental illness.
Dermatologic	Bites and stings. Burns and scalds. Wounds. Abscesses and local infections. Rashes.
Uro- or Gynaecological	Testicular pain. Urinary problems. Sexually acquired infection. Pregnancy. PV Bleeding.
Cardiac	Chest pain. Palpitations.
Other	Allergy. Dental problems. Diabetes. Exposure to chemicals. Eye problems. Foreign body. Major incidents – primary. Major incidents – secondary. General/other.

^aSubgroups of presenting problems (MTS Flowchart), based on a previous study (1)

Supplementary table 1.2 Presenting problems				
N (%)	Office hours (n=50,417)	Evening shift (n=36,429)	Night shift (n=14,138)	Day shift weekend (n=18,220)
General malaise	10,069 (20.0)	7,021 (19.3)	3,473 (24.6)	3,784 (20.8)
Trauma or muscular	9,785 (19.4)	7,281 (20.0)	1,161 (8.2)	3,111 (17.1)
Gastro-intestinal	7,613 (15.1)	5,274 (14.5)	2,860 (20.2)	2,470 (13.6)
Dermatologic	5,864 (11.6)	4,851 (13.3)	1,044 (7.4)	2,864 (15.7)
Respiratory	5,686 (11.3)	3,833 (10.5)	2,494 (17.6)	1,947 (10.7)
Ear, Nose, Throat	4,777 (9.5)	3,596 (9.9)	1,320 (9.3)	1,870 (10.3)
Neurologic or Psychiatric	2,115 (4.2)	1,384 (3.8)	628 (4.4)	566 (3.1)
Uro- or Gynaecological	1,126 (2.2)	800 (2.2)	240 (1.7)	416 (2.3)
Cardiac	635 (1.3)	438 (1.2)	177 (1.3)	148 (0.8)
Other	2,084 (4.1)	1,489 (4.1)	443 (3.1)	733 (4.0)
Missing	690 (1.4)	462 (1.3)	298 (2.1)	311 (1.7)

Supplement 2. Immediate life-saving interventions

Supplementary table 2. Immediate life-saving interventions^a

1. Airway and breathing support, including intubation or emergent non-invasive positive pressure ventilation.
2. Electrical therapy, including defibrillation, emergent cardioversion, or external pacing.
3. Procedures, including chest needle decompression, pericardiocentesis, or open thoracotomy.
4. Hemodynamic support, including significant intravenous fluid resuscitation in the setting of hypotension, blood administration, or control of major bleeding.
5. Emergency medications, including naloxone, dextrose, atropine, adenosine, epinephrine, or vasopressors

^aAdapted from Lee et. al.(2)

Supplement 3. Missing data for vital signs

The missing data for the vital signs variables (heart rate 42.7%, respiratory rate 52.4%, oxygen saturation 44.9%, temperature 22.5%) were assumed to be missing at random. We expected that the pattern of missingness could be explained by different patient and setting-related factors, that were included in the dataset. For example, based on clinical experience, measuring vital signs was considered less useful or relevant in low urgency cases or in patients with specific presenting problems, such as simple fractures. Also in high urgency cases data of vital signs was missing, which was not expected. This could be partly explained by data of vital signs that were not documented in the patient record, instead of vital signs that were not measured. The proportion of missing data for vital signs was comparable with previous studies. (3-5) A variety in the proportion of missingness was observed between the different hospitals, which is likely due to differences in characteristics of the patient populations and in local policies and compliance to these policies. (Supplementary figure 1) In exploratory analyses, strong associations were found between the proportion of missing data and several patient and hospital-related factors (type of presenting complaint, triage urgency and disposition after the ED visit), thereby supporting the assumption that the missing data for vital signs were missing at random.

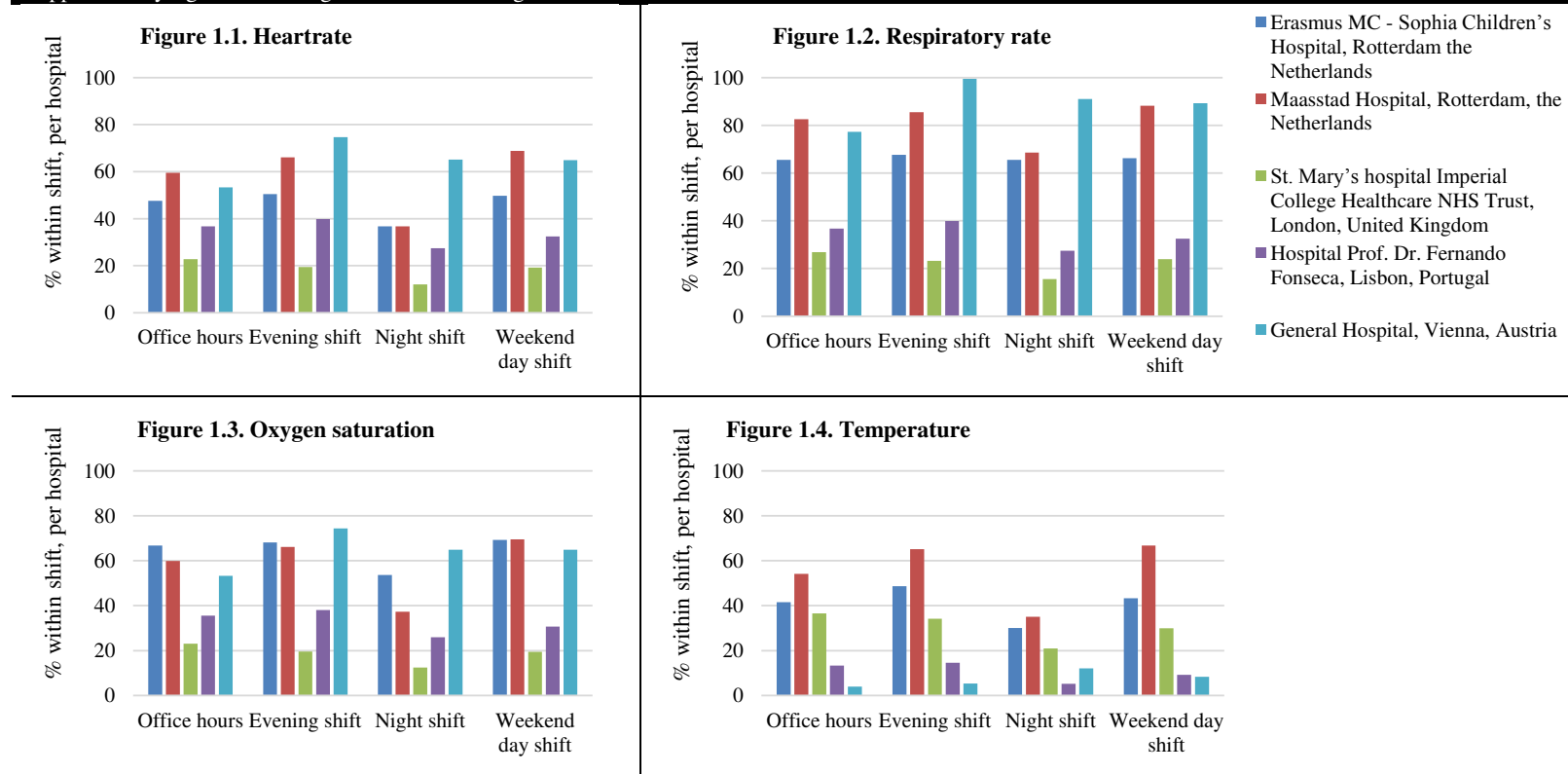
The missing data were imputed using a multiple imputation model including general patient characteristics, date and time of visit, triage items, vital signs, diagnostics, therapy and disposition. (Supplementary table 3)

Imputation was performed by using the MICE imputation package in R, version 2.15.2. The imputation process resulted in twenty-five datasets on which statistical analyses were performed and pooled for a final result.

Supplementary table 3. Multiple imputation model

Type of information	Variables
General patient characteristics	Hospital (cat); Age (cont.); Gender (M/F); Referral type (Self / GP / Emergency services / Other)
Date and time	Arrival month (1-12); Arrival hour (morning/evening/night); Arrival day (week/weekend)
Triage items	MTS flowchart (cat); MTS urgency (1-5); MTS pain score (cont)
Physiological parameters	Heart rate (cont); Respiratory rate (cont); Temperature (cont); Systolic blood pressure (cont); Diastolic blood pressure (cont); Saturation (cont); Capillary refill (dich); Consciousness (normal / decreased / unconsciousness);
Diagnostics, Therapy, Disposition	Any lab (Yes/No); Any imaging (Yes/No); Any cultures (Yes/No); Oxygen therapy (Yes/No); Oral meds (Yes/No); Inhalation meds (Yes/No); IV meds or fluids (Yes/No); Immediate lifesaving interventions (Yes/No); Disposition (Mortality or ICU admission/ Admission / Other (cat)

Supplementary figure 1. Missing data for the vital signs variables



Supplement 4. Complete case analyses

For the complete case analyses, we used a database consisting only of cases in which all vital signs (heart rate, respiratory rate, oxygen saturation and temperature) were measured and documented (total n=51,664). We performed the same regression analyses as with the imputation database, adjusted for age, gender, urgency, vital signs, presenting problem and hospital.

We found comparable results of the association between management and time of arrival at the ED, when comparing the results of the imputation dataset to the complete case dataset (Supplementary table 4). In the complete case analyses, imaging was less likely to be requested and treatment was more likely to be given during all out-of-office hours. During the night patients were significantly more likely to be admitted to the hospital. In complete case analyses, only the slightly lower number of laboratory diagnostics and slightly higher number of hospital admissions was not seen in weekend day shifts, but was confirmed in evening shifts. More chance variation in complete case analyses is likely to contribute to these differences. (6, 7)

Supplementary table 4 The association between management (lab, imaging, treatment, hospital and PICU^a admission) and time of arrival at the ED, adjusted regression analyses. Complete cases (vital signs).

Total, n = 51,664 aOR ^b (95% CI)	Office hours ^c (n=21,963)	Evening shift (n=7,800)	Night shift (n=14,251)	Day shift weekend (n=7,649)
Lab	-	0.95 (0.89 – 1.00)	0.88 (0.81 – 0.95) *	1.02 (0.95 – 1.10)
Imaging	-	0.85 (0.80 – 0.91) *	0.63 (0.58 – 0.68) *	0.92 (0.85 – 0.99)*
Treatment	-	1.11 (1.05 – 1.17) *	1.46 (1.37 – 1.55) *	1.17 (1.10 – 1.24) *
Hospital admission	-	1.05 (0.97 – 1.14)	1.27 (1.16 – 1.39) *	0.95 (0.86 – 1.05)

^a PICU = Paediatric Intensive Care Unit

^baOR = Adjusted Odds Ratio. Adjusted for age, gender, urgency, vital signs, presenting problem and hospital.

^c Office hours (= day shift week) as reference shift.

* P-value ≤0.05. If not stated: p-value >0.05

Supplement 5. Hospital characteristics

Supplementary table 5.1 Patient characteristics - Erasmus MC - Sophia Children's Hospital, Rotterdam the Netherlands

	Office hours ^a	Evening shift	Night shift	Day shift weekend
(Total, n=18,590)	(n=8,915)	(n=5,055)	(n=1,618)	(n=3,002)
Median age, yrs (IQR^b)	4.6 (1.4 – 10.2)	4.1 (1.4 – 9.4)	3.7 (1.2 – 9.3)	4.2 (1.5 – 9.2)
Gender, n (%)				
- Male	5,098 (57.2)	2,956 (58.5)	957 (59.1)	1,760 (58.6)
MTS, n (%)				
- High urgent	1,073 (12.0)	655 (12.9)	356 (22.0)	343 (11.4)
- Urgent	4,040 (45.3)	2,502 (49.5)	741 (45.8)	1,461 (48.7)
- Low urgent	3,462 (38.8)	1,762 (34.8)	492 (30.4)	1,133 (37.7)
- Missing	340 (3.8)	136 (2.7)	29 (1.8)	65 (2.2)
Vital signs, n (%)				
- Normal	2,925 (32.8)	1,559 (30.9)	440 (27.2)	962 (32.1)
- 1 Abnormal	3,885 (43.6)	2,114 (41.8)	681 (42.1)	1,289 (42.9)
- 2 or more abnormal	2,105 (23.6)	1,381 (27.3)	497 (30.7)	751 (25.0)

^aOffice hours = Day shift week^bIQR = Interquartile range^cMTS = Manchester Triage System

Supplementary table 5.2 Patient characteristics - Maasstad Hospital, Rotterdam, the Netherlands

	Office hours ^a	Evening shift	Night shift	Day shift weekend
(Total, n=10,583)	(n=4,229)	(n=3,630)	(n=981)	(n=1,743)
Median age, yrs (IQR^b)	5.5 (1.8 – 11.4)	6.2 (2.2 – 11.7)	3.8 (1.0 – 10.5)	6.7 (2.5 – 11.9)
Gender, n (%)				
- Male	2,384 (56.4)	1,999 (55.1)	573 (58.4)	1,048 (60.1)
MTS, n (%)				
- High urgent	586 (13.9)	477 (13.2)	255 (26.0)	197 (11.3)
- Urgent	2,023 (47.8)	1,788 (49.3)	449 (45.8)	850 (48.8)
- Low urgent	1,567 (37.1)	1,339 (36.9)	267 (27.2)	684 (39.2)
- Missing	53 (1.3)	26 (0.7)	10 (1.0)	12 (0.7)
Vital signs, n (%)				
- Normal	1,305 (30.9)	1,076 (29.7)	250 (25.5)	540 (31.0)
- 1 Abnormal	1,839 (43.5)	1,526 (42.0)	387 (39.4)	747 (42.9)
- 2 or more abnormal	1,085 (25.6)	1,028 (28.3)	344 (35.1)	456 (26.1)

^aOffice hours = Day shift week^bIQR = Interquartile range^cMTS = Manchester Triage System

Supplementary table 5.3 Patient characteristics - St. Mary's hospital Imperial College Healthcare NHS Trust, London, United Kingdom

	Office hours ^a	Evening shift	Night shift	Day shift weekend
(Total, n=15,556)	(n=5,635)	(n=4,847)	(n=2,429)	(n=2,645)
Median age, yrs (IQR^b)	4.3 (1.5 – 9.6)	4.0 (1.5 – 8.9)	3.4 (1.3 – 7.4)	3.7 (1.5 – 7.7)
Gender, n (%)				
- Male	3,137 (55.7)	2,736 (56.4)	1,328 (54.7)	1,476 (55.8)
MTS, n (%)				
- High urgent	567 (10.1)	494 (10.2)	312 (12.8)	232 (8.7)
- Urgent	1,456 (25.8)	1,318 (27.2)	568 (23.4)	619 (23.4)
- Low urgent	3,612 (64.1)	3,035 (62.6)	1,549 (63.8)	1,794 (67.9)
- Missing	0 (0.0)	0 (0.0)	0 (0)	0 (0)
Vital signs, n (%)				
- Normal	2,494 (44.3)	2,138 (44.1)	1,008 (41.5)	1,167 (44.1)
- 1 Abnormal	2,152 (38.2)	1,801 (37.2)	887 (36.5)	1,010 (38.2)
- 2 or more abnormal	989 (17.5)	909 (18.7)	534 (22.0)	468 (17.7)

^aOffice hours = Day shift week^bIQR = Interquartile range^cMTS = Manchester Triage System**Supplementary table 5.4 Patient characteristics - Hospital Prof. Dr. Fernando Fonseca, Lisbon, Portugal**

	Office hours ^a	Evening shift	Night shift	Day shift weekend
(Total, n=53,175)	(n=22,470)	(n=16,422)	(n=6,879)	(n=7,404)
Median age, yrs (IQR^b)	5.2 (2.1 – 10.1)	4.7 (2.0 – 9.4)	3.8 (1.5 – 7.9)	4.3 (1.9 – 8.5)
Gender, n (%)				
- Male	11,765 (52.4)	8,567 (52.2)	3,513 (51.1)	3,840 (51.9)
MTS, n (%)				
- High urgent	2,310 (10.3)	1,935 (11.8)	1,191 (17.8)	756 (10.2)
- Urgent	4,281 (19.1)	3,844 (23.4)	1,445 (21.0)	1,381 (18.7)
- Low urgent	15,879 (70.6)	10,643 (64.8)	4,213 (61.3)	5,267 (71.1)
- Missing	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Vital signs, n (%)				
- Normal	8,740 (38.9)	5,924 (36.1)	2,374 (34.5)	2,700 (36.5)
- 1 Abnormal	10,435 (46.4)	7,608 (46.3)	3,145 (45.7)	3,500 (47.3)
- 2 or more abnormal	3,295 (14.7)	2,890 (17.6)	1,359 (19.8)	1,204 (16.2)

^aOffice hours = Day shift week^bIQR = Interquartile range^cMTS = Manchester Triage System

Supplementary table 5.5 Patient characteristics – General Hospital, Vienna, Austria

	Office hours ^a	Evening shift	Night shift	Day shift weekend
(Total, n=21,300)	(n=9,168)	(n=6,475)	(n=2,231)	(n=3,426)
Median age, yrs (IQR^b)	4.0 (1.6 – 8.5)	3.8 (1.5 – 8.4)	3.7 (1.4 – 8.3)	3.8 (1.7 – 7.6)
Gender, n (%)				
- Male	4,766 (52.0)	3,440 (53.1)	1,195 (53.6)	1,832 (53.5)
MTS, n (%)				
- High urgent	427 (4.6)	343 (5.3)	158 (7.1)	155 (4.5)
- Urgent	1,500 (16.4)	1,344 (20.8)	452 (20.3)	555 (16.2)
- Low urgent	6,958 (75.9)	4,297 (69.5)	1,371 (61.4)	2,488 (72.6)
- Missing	283 (3.1)	290 (4.5)	250 (11.2)	228 (6.7)
Vital signs, n (%)				
- Normal	3,271 (35.7)	2,206 (34.1)	739 (33.1)	1,183 (34.5)
- 1 Abnormal	4,233 (46.2)	2,899 (44.7)	1,000 (44.8)	1,573 (45.9)
- 2 or more abnormal	1,664 (18.1)	1,371 (21.2)	493 (22.1)	670 (19.6)

^aOffice hours = Day shift week^bIQR = Interquartile range^cMTS = Manchester Triage System

Supplement 6. Stratified regression analyses

Supplementary table 6. Management adjusted regression analyses, per hospital					
	Erasmus MC - Sophia Children's Hospital, Rotterdam the Netherlands	Maastad Hospital, Rotterdam, the Netherlands	St. Mary's hospital Imperial College Healthcare NHS Trust, London, United Kingdom	Hospital Prof. Dr. Fernando Fonseca, Lisbon, Portugal	General Hospital, Vienna, Austria
Total n=119,204 aOR ^a (95% CI)	n = 18,590	n = 10,583	n = 15,556	n = 53,175	n = 21,300
Lab					
- Evening shift	0.75 (0.69 – 0.82) *	0.82 (0.71 – 0.94) *	0.73 (0.63 – 0.83)*	1.00 (0.94 – 1.07)	0.61 (0.57 – 0.66) *
- Night shift	0.77 (0.68 – 0.87) *	0.86 (0.71 – 1.04)	0.71 (0.60 – 0.84) *	1.03 (0.95 – 1.11)	0.68 (0.61 – 0.77) *
- Day shift weekend	0.90 (0.81 – 0.99)*	0.85 (0.71 – 1.02)	0.68 (0.57 – 0.81)*	1.15 (1.07 – 1.25) *	0.82 (0.74 – 0.90) *
Imaging					
- Evening shift	0.73 (0.67 – 0.80) *	2.18 (1.93 – 2.47) *	0.77 (0.68 – 0.87) *	0.94 (0.88 – 0.99) *	0.59 (0.52 – 0.68) *
- Night shift	0.53 (0.46 – 0.62)*	1.05 0.84 – 1.30	0.52 (0.43 – 0.62) *	0.68 0.63 – 0.74 *	0.55 (0.44 – 0.67)*
- Day shift weekend	0.85 (0.76 – 0.94)	2.00 (1.72 – 2.34) *	0.81 (0.69 – 0.94) *	0.94 (0.88 – 1.02)	1.00 (0.86 – 1.16)
Treatment					
- Evening shift	1.13 (1.04 – 1.22) *	0.78 0.68 – 0.89) *	1.35 (1.25 – 1.47)*	0.99 (0.93 – 1.04)	1.44 (1.32 – 1.58) *
- Night shift	1.32 (1.17 – 1.50)*	1.03 (0.86 – 1.24)	1.55 (1.40 – 1.72) *	1.53 (1.43 – 1.64) *	2.32 (2.06 – 2.62) *
- Day shift weekend	1.12 1.01 – 1.23*	0.89 (0.75 – 1.06)	1.31 (1.19 – 1.54) *	1.12 (1.03 – 1.21) *	1.38 (1.23 – 1.55) *
Hospital admission					
- Evening shift	1.20 (1.09 – 1.31) *	1.05 (0.93 – 1.18)	0.92 (0.80 – 1.06)	1.05 (0.95 – 1.16)	0.93 (0.80 – 1.09)
- Night shift	1.43 (1.25 – 1.63) *	1.44 (1.22 – 1.71) *	0.95 (0.80 – 1.19)	1.51 (1.35 – 1.69) *	1.06 (0.86 – 1.30)
- Day shift weekend	1.15 (1.03 – 1.29) *	1.04 (0.89 – 1.21)	0.71 (0.59 – 0.85)*	1.09 (0.95 – 1.24)	1.32 (1.10 – 1.58) *

^aaOR = Adjusted Odds Ratio. Adjusted for age, gender, urgency level, abnormal vital signs, presenting problem

*P-value ≤0.05. If not stated: p-value >0.05

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