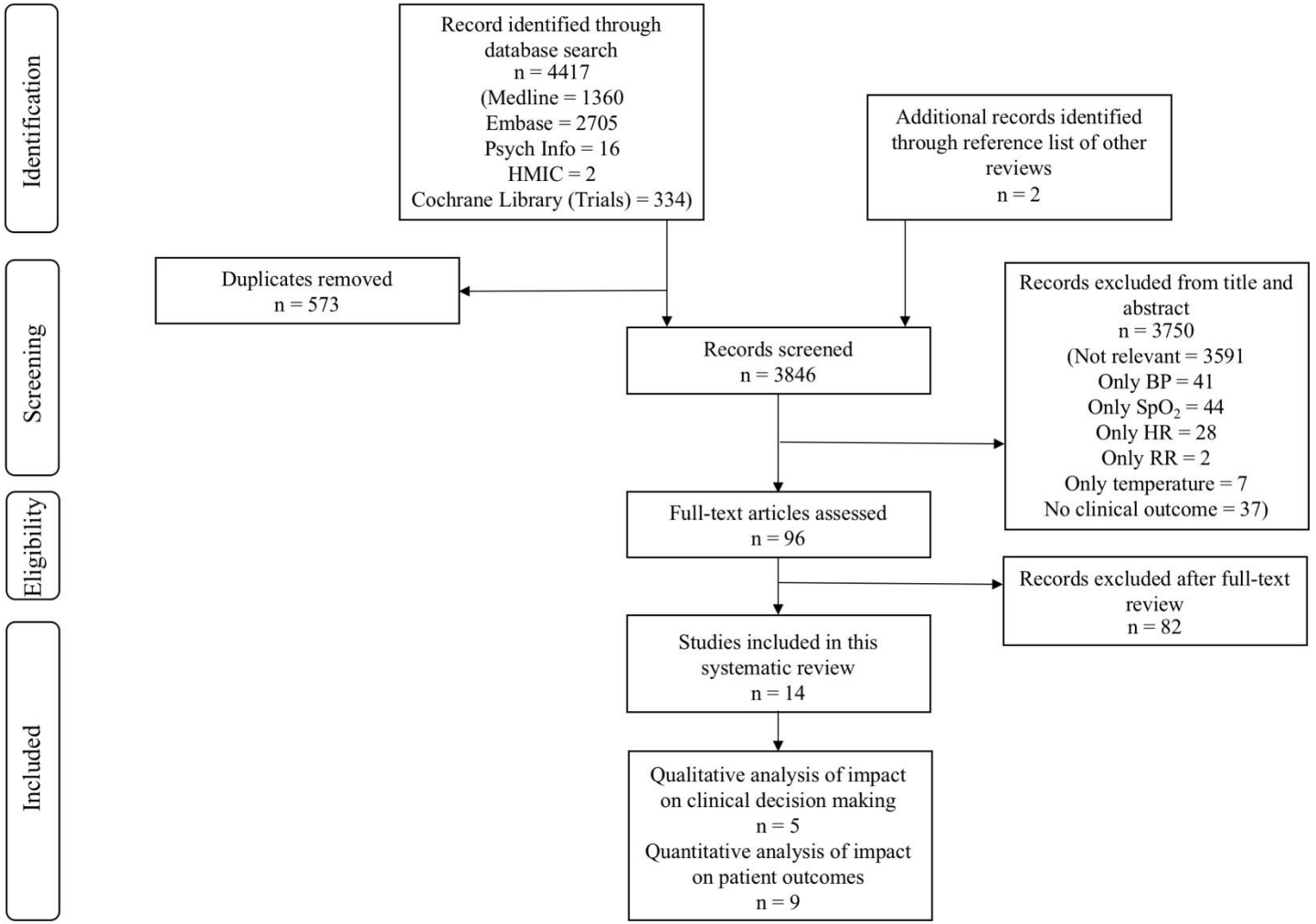
Supplemental Figure 1 Prisma Chart



Supplemental Table 1 Studies on Associations of Multi-Parameter CoNiM to Clinical Parameters (Group A)

Summary table of Group A studies.

Study	n	Type of trial	Device	Vital Signs Measured (Derived Parameters)	Patient Group	Clinical Variable	Results	Reference
Kanaoka et al, 2012	25	Prospective data collection and retrospective analysis	TM-2425, A&D, Tokyo, Japan	BP, HR	Hospitalised hypertensive patients with CKD	Renal function - Urine Albumin Excretion Rate (UACR) and eGFR	UACR: 24-hour (p-value = 0.001), daytime (p-value = 0.009), and night-time (p-value < 0.001) ambulatory systolic BP, 24-hour (p-value = 0.007) and daytime (p-value = 0.016) HR variability. eGFR: 24-hour (p-value = 0.017) and night-time (p-value = 0.008) HR variability, and night-time HR (p-value = 0.038)	39
Zimlichman et al, 2012	113	Prospective data collection and retrospective analysis	Earlysense monitor	HR, RR	Medical ward (Patients with acute respiratory condition)	ICU transfer; intubation or mechanical ventilation; cardiac arrest in unit	ROC curve (combined HR & RR) - alerts: AUC = 0.75, p-value < 0.0001; trends: AUC = 0.93, p-value < 0.0026	40
Nowak et al, 2014	510	Prospective data collection and retrospective analysis, blinded	Nexfin	BP, HR (CO, CI, SV, SVI, SVR, SVRI)	ED patients suspected acute heart failure, sepsis, stroke	Acute Heart Failure, Sepsis or Stroke diagnosis; 30-Day mortality of each patient group[∂]	SBP, DBP, Mean BP, HR, CO, CI, SVR, SVRI: all p-value < 0.0001; SVI: p-value = 0.0361; SV: p-value = 0.3737; 30-Day mortality SVI ROC curve: AHF: AUC=0.73, p-value < 0.01; sepsis: AUC=0.687, p-value < 0.01; stroke: AUC=0.741, p-value < 0.05	25
Hubner et al, 2015	226	Prospective data collection and retrospective analysis	IntelliVue Cableless Measurement Pods	RR, HR, SpO2, BP	Emergency department waiting room	Clinical symptom categories: dyspnoea, chest pain, hypertension, palpitation, collapse	SpO2: dyspnoea compared to chest pain p-value = 0.022; BP: hypertension compared to chest pain, palpitation and collapse all p-value < 0.001 while compared to dyspnoea p-value = 0.004; RR: dyspnoea compared to all other groups all p-value < 0.001; HR: palpitations compared to chest pain p-value < 0.001 and to collapse p-value = 0.024	38
Nowak et al, 2016	127	Prospective data collection and retrospective analysis, blinded	Nexfin	BP, HR (CI, SVRI)	ED patients with confirmed systemic infection	Three different clusters of sepsis patients; 30-Day mortality, LOS, of each patient group[∂]	CI and SVRI: all p-value < 0.0001; 30-Day mortality: p-value = 0.0311; LOS: p-value = 0.5801	24

[∂]In Nowak et al, 2014 and Nowak et al, 2016, clinical outcomes (i.e. 30-day mortality and hospital LOS) were only analysed within each patient cluster. Therefore they were excluded from Group B meta-analysis.

Abbreviations HR, heart rate; BP, blood pressure; RR, respiratory rate; SpO2, peripheral capillary oxygen saturation; CO, cardiac output; CI, cardiac index; SV, stroke volume; SVI, stroke volume index; SVR, systemic vascular resistance; SVRI, systemic vascular resistance index; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; ICU, intensive care unit; ED, emergency department; LOS, length of stay.

Supplemental Table 2 Studies on Clinical Outcome of Multi-Parameter CoNiM (Group B)

Summary table of Group B studies.

Study	Type of trial	Total n	Device	Vital Signs	Patient Group (n)	Control[§] (n)	In-hospital Mortality	Hospital LOS	ICU Transfer	RRT Activation	NOS	Reference
Sulter et al, 2003	Prospective, parallel-grouped, randomised cohort study	54	Marquette Eagle 4000	HR, BP, SpO2, Temperature	Stroke ward (27)	Concurrent (27)	✔	✔			8	42
Cavallini et al, 2003	Prospective, parallel-grouped, randomised cohort study	268	Unknown	HR, BP, RR, SpO2, Temperature	Stroke ward (134)	Concurrent (134)	✔	✔			8	43
Kisner et al, 2008	Retrospective cohort study	357	Auricall	HR, SpO2	Heart and vascular surgery ward postoperatively (119)	Pre-intervention phase (238)					7	47
Langhorne et al, 2010	Prospective, parallel-grouped, randomised cohort study	32	Welch Allyn	HR, BP, SpO2, Temperature	Stroke ward (16)	Concurrent (16)	✔				8	44
Brown et al, 2014	Prospective, parallel-grouped, randomised cohort study	7643	EarlySense system	HR, RR	Medical-surgical ward (2361)	Pre-intervention phase and concurrent[†] (5282)			✔	✔	9	45
Pearl et al, 2016	Prospective cohort study	231	Phillips MP5SC	Multiple vital signs*	General hospital wards (80)	Pre-intervention phase (151)	✔				8	46
Weller et al, 2017	Prospective cohort study	2937	Sotera VisiMobile	HR, BP, RR, SpO2	Neuro/Neuro-Surgical ward, general hospital wards (1069)	Pre-intervention phase and concurrent[†] (2887)	✔	✔	✔	✔	9	26
Downey et al, 2018	Prospective, parallel-grouped, cluster-randomised cohort study	350	Sensium Vitals	HR, RR, Temperature	Elective general surgery wards (140)	Concurrent (86)		✔			8	41
Verrillo et al, 2018	Prospective with retrospective review of control group, cohort study	849	Sotera VisiMobile	HR, BP, RR, SpO2, Temperature	Orthopedic and trauma general care ward (422)	Pre-intervention phase (427)	✔		✔	✔	8	48

*Did not specify vital signs monitored.

[§]Concurrent implies same period but in a different ward while pre-intervention phase implies different period but in the same ward as intervention ward.

[†]Also includes a control group during pre-intervention phase but in the ward used by the concurrent control group; therefore in Brown et al, 2014, only 1535 control patients from the intervention ward but during pre-intervention phase were included in this meta-analysis; likewise only 889 control patients were included from Weller et al, 2017.

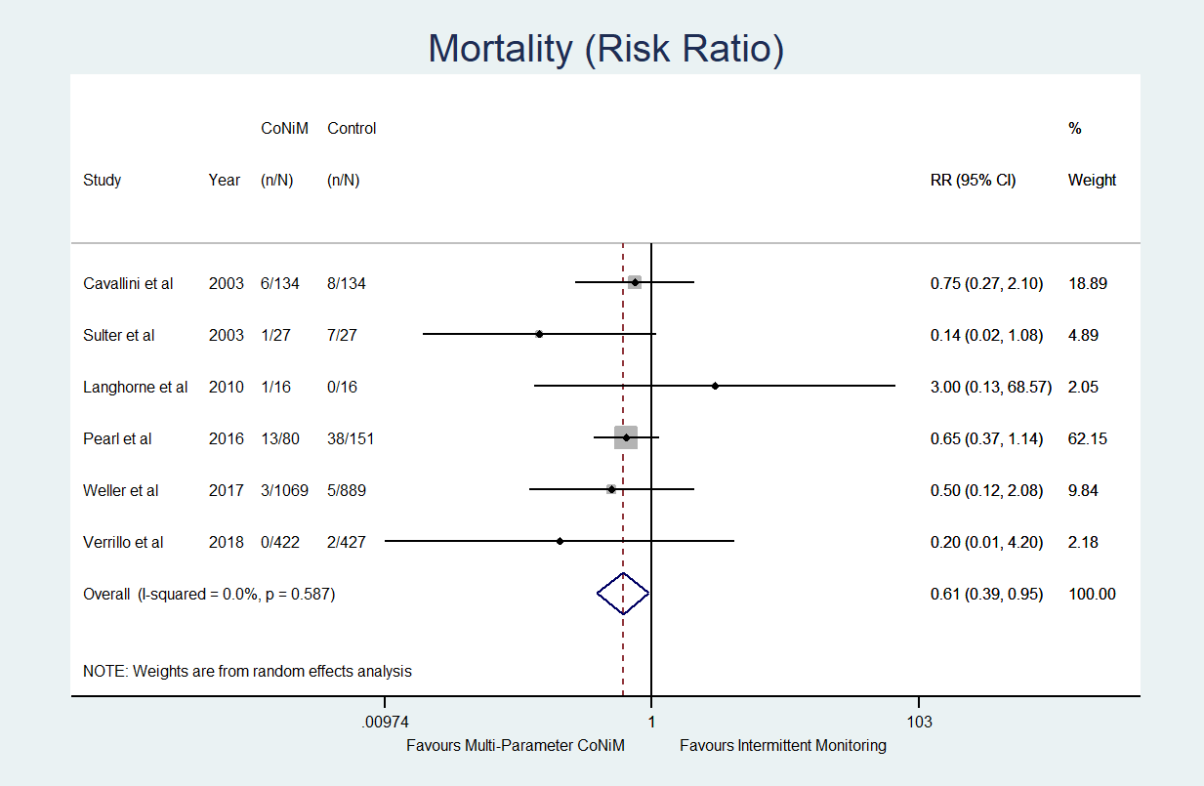
Abbreviations HR, heart rate; BP, blood pressure; RR, respiratory rate; SpO2, peripheral capillary oxygen saturation.

Supplemental Table 3 Nottingham-Ottawa Scale Analysis

Summary of Nottingham-Ottawa Scale analysis on Group B studies.

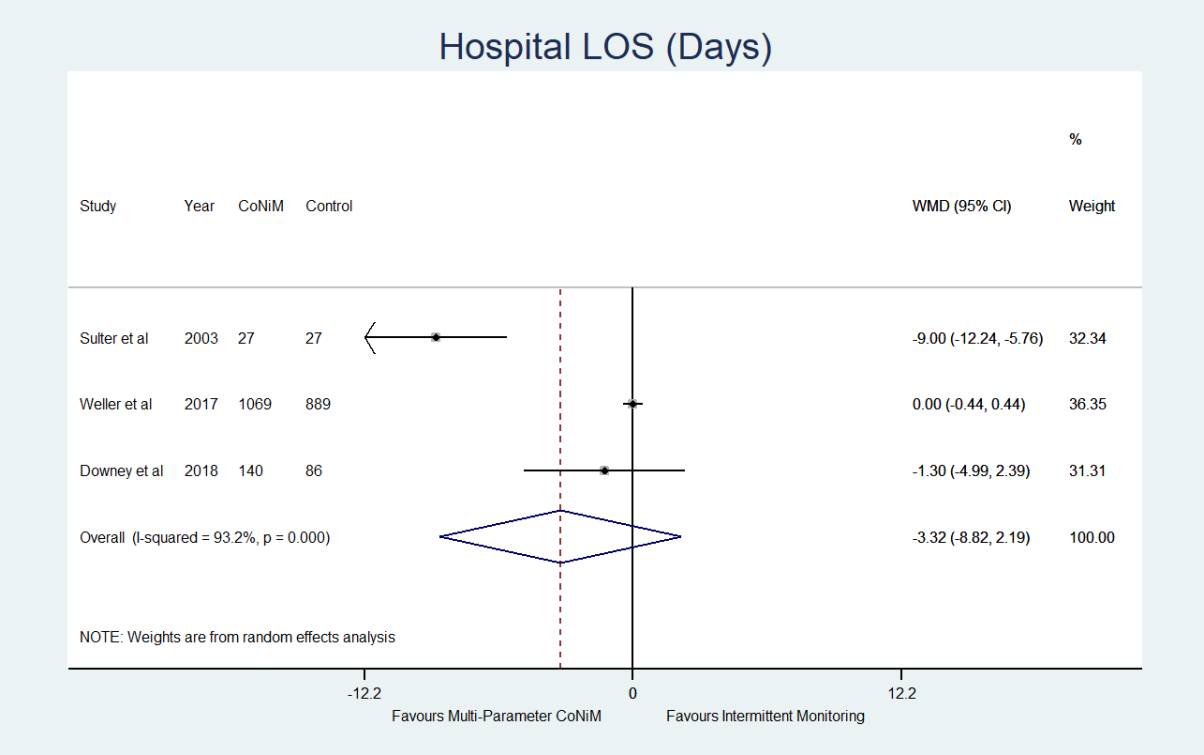
Study	Representative of exposed cohort	Representative of control cohort	Ascertainment of exposure	Absence of outcome at start of study	Study controls for study design	Study controls for analysis	Assessment of outcome	Duration of Follow-up	Adequacy of follow-up	Score
Sulter et al, 2003	1	1	1	1	1	1	1	1	1	8
Cavallini et al, 2003	1	1	1	1	1	1	1	1	1	8
Kisner et al, 2008	0	1	1	1	1	1	1	1	1	7
Langhorne et al, 2010	0	1	1	1	1	1	1	1	1	7
Brown et al, 2014	1	1	1	1	2	1	1	1	1	9
Pearl et al, 2016	1	1	1	1	1	1	1	1	1	8
Weller et al, 2017	1	1	1	1	2	1	1	1	1	9
Downey et al, 2018	1	1	1	1	1	1	1	1	1	8
Verrillo et al, 2018	1	1	1	1	1	1	1	1	1	8

Supplemental Figure 2.1



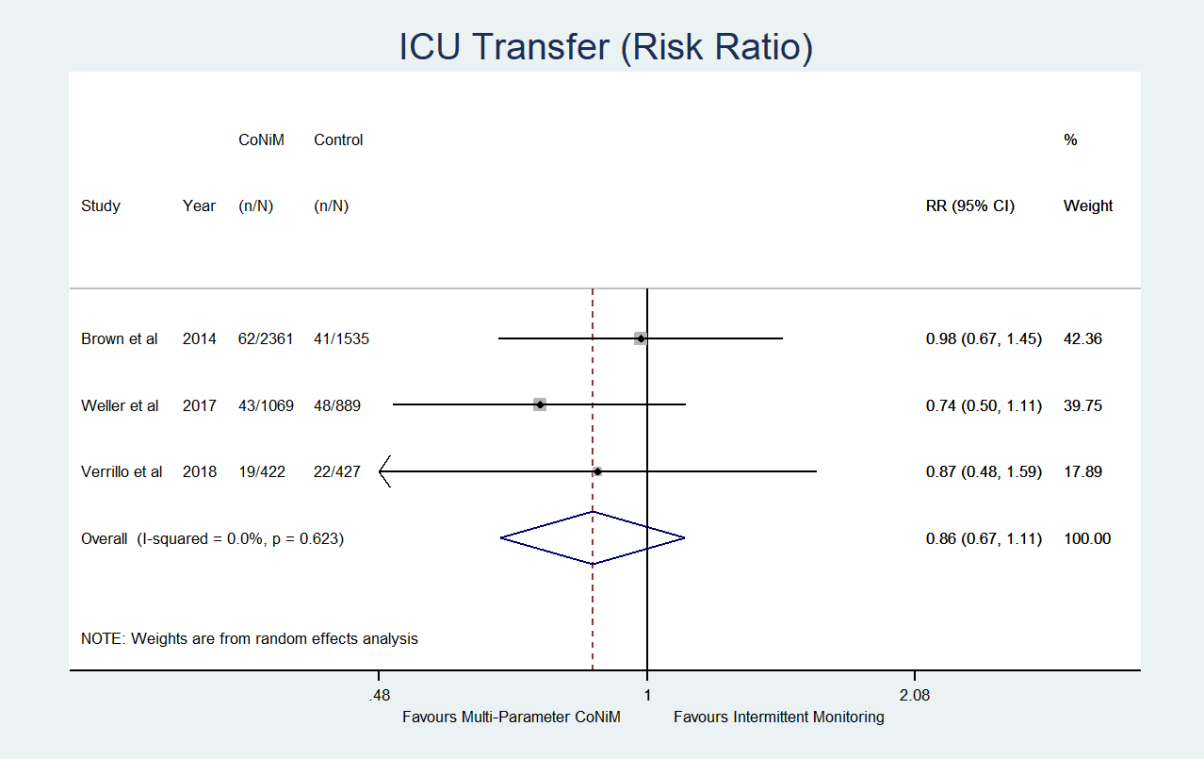
Forest plot of mortality risk ratio. n, positive cases; N, sample size.

Supplemental Figure 2.2



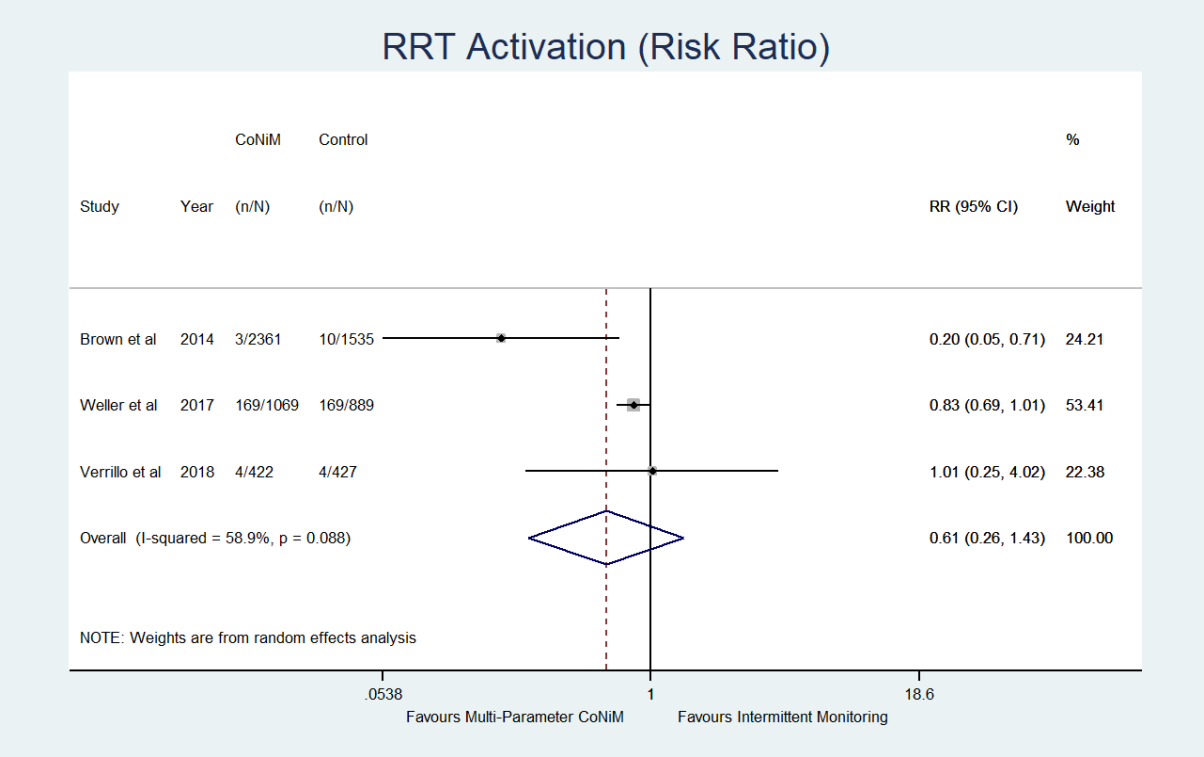
Forest plot of weighted mean difference (WMD) in hospital LOS.

Supplemental Figure 2.3



Forest plot of ICU transfer risk ratio. n, positive cases; N, sample size.

Supplemental Figure 2.4



Forest plot of RRT activation risk ratio. n, positive cases; N, sample size.

Appendix A (Search Strategy)
Search was performed on 18th June 2019.

Concept: Continuous monitoring
Continuous monitor*
Wear* adj3 Sensor?
Wearable system?
Wearable technolog*
Remote sensor?
Patient* adj3 sensor?
Mobile sensor?
Ambulatory sensor?
Wear* adj3 Detector*
Remote detector*
Patient* adj3 Detector*
Mobile detector*
Ambulatory Detector*
Telemetr*
Chest belt*
Abdominal belt*
Bend Sensor*
Oximetr*
Thermometer*
Thermometre*
[Embase MeSH] Monitor; electronic device; general medical device; cardiovascular monitoring device; patient monitor; personal monitor; blood pressure monitor; cardiovascular monitoring device; non invasive blood pressure monitor; blood pressure alarm; telemetry; exp remote sensing; temperature measurement; exp body temperature measurement; exp body temperature monitoring; patient monitoring; ambulatory monitoring; apnea monitoring; cardiovascular monitoring device; cardiotachometer
[Medline MeSH] Monitoring, physiologic; hemodynamic monitoring; monitoring, ambulatory; blood pressure monitoring, ambulatory; telemetry; remote sensing technology
[HMIC MeSH] Patient monitoring equipment; patient monitoring; medical telemetering equipment; telemetry
[PsychINFO MeSH] Monitoring; telemetry
[Cochrane MeSH, explode all trees] Wearable electronic devices, telemetry, oximetry, thermometers
Concept: Hospital
Hospital*
Ward*
Inpatient*
[Embase MeSH] Hospital; community hospital; general hospital; geriatric hospital; high volume hospital; private hospital; public hospital; teaching hospital; university hospital
[Medline MeSH] Academic medical centers; hospitals, teaching; hospitals, university; hospital units; hospitals; hospitals, community; hospitals, general; hospitals, group practice; hospitals, high-volume; hospitals, low-volume; hospitals, private; hospitals, public; hospitals, county; hospitals, district; hospitals, federal; hospitals, military; hospitals, veterans; hospitals, municipal; hospitals, state; hospitals, rural; hospitals,

satellite; hospitals, chronic disease; hospitals, urban; secondary care centers; tertiary care centers
[HMIC MeSH] Hospitals; civil defence hospitals; community hospitals; day hospitals; district general hospitals; emergency hospitals; general hospitals; independent hospitals; large hospitals; local authority hospitals; long stay hospitals; medium sized hospitals; medium stay hospitals; military hospitals; modern hospitals; national hospitals; new hospitals; night hospitals; non teaching hospitals; nucleus hospitals; patient focussed hospitals; regional hospitals; rural hospitals; satellite hospitals; specialist hospitals; teaching hospitals; whole hospitals
[PsychINFO MeSH] Hospitals; hospitalized patients
[Cochrane MeSH, explode all trees] Inpatients, Patients' rooms
Concept: Vital signs
Vital sign*
Early warning system*
Early warning scor*
MEWS
EWS
National early warning score
EWSS
Track and trigger system*
TTS
Risk assessment tool*
Physiolog* adj4 state*
Physiolog* adj4 information
Physiolog* adj4 marker*
Physiolog* adj4 parameter*
Physiolog* adj4 parametre*
Oxygen sat*
Blood pressure*
Heart adj4 rate*
Heart adj4 beat*
Pulse
H?emodynamic*
Bod* adj4 temperature
Skin adj4 temperature
Respirat* adj4 rate*
Rapid Response
[Embase MeSH] Vital sign; hemodynamic parameters; blood pressure; diastolic blood pressure; pulse pressure; systolic blood pressure; body temperature; axilla temperature; basal body temperature; mouth temperature; tympanic temperature; "heart rate and rhythm"; heart rhythm; pulse rate; pulse wave; sinus rhythm; heart rate; heart rate variability; resting heart rate, breathing rate
[Medline MeSH] Vital signs; blood pressure; body temperature; heart rate; respiratory rate; early diagnosis; Patient Safety; Clinical Alarms
[HMIC MeSH] Blood pressure; blood pressure measurement; body temperature; heart rate; haemodynamics; respirometers; early diagnosis
[PsychINFO MeSH] Blood pressure; body temperature; skin temperature; heart rate; respiration; early intervention

[Cochrane MeSH, explode all trees] Vital Signs, Hemodynamic monitoring, blood pressure monitors, body temperature, heart rate, respiratory rate
Concept: Adult
Adult*
[Embase MeSH] Adult
[Medline MeSH] exp Adult
[HMIC MeSH] Adults; middle aged people; older people; young adults; adult physiology
[PsychINFO MeSH] -
[Cochrane MeSH, explode all trees] Adult
Concept: Patient outcomes
Mortality
Deteriorat*
Discharge*
Recover*
Recuperat*
diagnos* adj3 accurac*
early diagnosis
transfer* adj4 ITU
transfer* adj4 ICU
transfer* adj4 intensive care unit?
transfer* adj4 intensive treatment unit?
transfer* adj4 intensive therapy unit?
move* adj4 ITU
move* adj4 ICU
move* adj4 intensive care unit?
move* adj4 intensive therapy unit?
move* adj4 intensive treatment unit?
morbidity
sepsis
septic
cardiac arrest
respiratory distress
Bacter?emia
Patient outcome
[Embase MeSH] exp treatment outcome; exp adverse outcome; exp outcome assessment; exp outcome variable; exp Glasgow outcome scale; exp patient-reported outcome; exp general condition deterioration; exp morbidity; exp sepsis; exp septic shock; exp bacteremia
[Medline MeSH] exp disease-free survival; exp treatment outcome; exp "Outcome Assessment (Health Care)"; exp Glasgow Coma Scale; exp CLINICAL DETERIORATION; exp MORBIDITY; exp HOSPITAL MORTALITY; exp MORTALITY; exp SEPSIS; exp Shock, Septic; exp BACTEREMIA
[HMIC MeSH] exp Patient outcome; outcomes; exp health outcomes; exp outcome measurement; exp outcome measures; exp performance; exp Deterioration; exp Morbidity; exp Mortality; exp Sepsis
[PsychINFO MeSH] exp Treatment Outcomes; exp MORBIDITY; exp "death and dying"; exp Inflammation

[Cochrane MeSH, explode all trees] Adverse outcome pathways, fatal outcome, patient outcome assessment, critical care outcomes, sepsis, clinical deterioration, heart arrest, respiratory distress syndrome (adult)