

Supplementary Material

APPENDIX 1 Preliminary search for protocol

We will search MEDLINE (Ovid), Embase (embase.com)¹, CINAHL Complete (Ebscohost), Cochrane Library (wiley.com) including CENTRAL (wiley.com), and IEEE Xplore (IEEE.org). All searches will cover a timeframe between January 1 2009 to the present.

Because of the complex, multi-disciplinary, and emerging vocabulary related to automated surveillance for patient deterioration, and the need to limit the expansive literature on this topic to studies that incorporate evaluation of an implemented approach, our search query is complex, targeting multiple intersecting concepts. Medline is our primary database and our search is highly sensitive to our research question. Search strategies for the other four databases will include more precision and not be as sensitive. We will use an iterative process of adapting our MEDLINE search to the functions and capabilities of Embase, CINAHL, CENTRAL, and IEEE Xplore after the MEDLINE search is finalized. Our preliminary MEDLINE (Ovid) search is detailed below.

The final searches for all databases will be provided with our published findings.

#	Query Ovid MEDLINE(R)	Concepts / Sets
1	Clinical Deterioration/	
2	(((((clinical or patient* or inpatient* or hospitalized or hospitalised or in-hospital or "in hospital") adj6 (deteriorat* or "adverse event*" or "serious event*")) or "early mortality").ti,ab,kw.	
3	or/1-2 [Pt deterioration set 1]	Patient Deterioration
4	monitoring, physiologic/ or hemodynamic monitoring/ or neurophysiological monitoring/	
5	((monitor* adj2 (haemodynamic* or hemodynamic* or neurophysiologic* or physiologic* or patient*)) or electrocardiograph* or ECG or ECGs or EKG or EKGs or "vital sign*").ti,ab,kw. [monitoring keywords 1]	
6	((monitor* adj3 (continuous or intermittent* or patient* or inpatient* or predictive* or "vital sign*")) or (predict* adj3 (analytic* or monitor*))).ti,ab,kw. [monitoring keywords 2]	
7	("patient monitor*" or "Alaris PC unit" or "Avalon Patient Module" or "CARESCAPE Central Station" or "clinical multiple physiological parameter spot-check analysis system" or "Datascope 3000" or "EarlySense BEX Sensor" or "Efficia CMS200" or "EV-1000" or "IntelliBridge EC10 Module" or "IntelliBridge EC5 ID-Module" or "IntelliVue Capnography extension" or "IntelliVue FMS-4" or "interfacing patient monitoring system module" or "multifunction patient monitoring system module" or "multiple physiological parameter spot-check analysis system" or "patient data management	

	system" or ("patient monitor*" adj2 ("central station" or device* or modem* or module* or system or systems)) or ("patient vital sign*" adj2 module) or Physioloris or "physiologic* monitor*" or "Solar 8000i" or "SureSigns VSV or Vigeleo" or "Vigilance Monitor" or (bispebjerg or "physiological scoring system" or worthing or vialpac or sbar or "situation background assessment recommendation" or mews or "manchester triage system" or biosign)).ti,ab,kw. [pt monitoring keywords set]	
8	or/4-7 [monitoring set]	Patient Monitoring
9	Clinical Alarms/ or ("alarm monitor*" or ((automat* or computer* or bedside* or clinical or dashboard* or early or electronic* or inpatient* or in-patient* or multi-patient* or patient* or "physiologic* monitor*" or real-time or "real time" or single-patient*) adj3 (alarm* or alert* or monitor* or surveillance* or warning*)) or "track and trigger*" or "trigger tool*").ti,ab,kw. [Clinical alarms set]	
10	((alarm* or alert* or monitor* or surveillance or warning*) adj2 (automat* or clinical or early or electronic or real-time or "real time")).ti,ab,kw. [alarm set]	
11	Point-of-Care Systems/ or Point-of-Care Testing/ or Hospital Information Systems/ or ("point of care" or point-of-care or bedside or "bed side").ti,ab,kw. [Point of care set]	
12	or/9-11 [Clinical alarm/Point of care set]	Clinical Alarms / Point of Care
13	exp risk/ or risk adjustment/ or safety management/ or (risk or risks or predict*).ti,ab,kw. [Risk/predict set]	Risk/predict
14	acute disease/ or critical illness/ or emergencies/ [critical illness Mesh terms]	
15	((acute* or catastrophic* or critical* or emergenc*) adj2 (care or disease* or ill or illness*)).ti,ab,kw. [critical illness keyword terms]	
16	critical care/ or early goal-directed therapy/ or intensive care, neonatal/ [critical care MeSH terms]	
17	((catastrophic* or critical* or early or intensive) adj2 care) or "goal-directed therap*").ti,ab,kw. [critical care keyword terms]	
18	intensive care units/ or burn units/ or coronary care units/ or intensive care units, pediatric/ or intensive care units, neonatal/ or recovery room/ or respiratory care units/ [intensive care units MeSH terms]	
19	((acute* or catastrophic* or critical* or intensive*) adj2 (care or unit* or ward)).ti,ab,kw. [intensive care keyword terms]	
20	Hospital Rapid Response Team/	
21	("code team*" or "crash team*" or ((code or crash or "critical care" or emergen* or "intensive care" or "rapid response" or trauma) adj3 team*)).ti,ab,kw.	

22	emergency service, hospital/ or trauma centers/ or ("emergency service*" adj2 hospital*) or (trauma adj2 (center* or service*)) or traumatolog*).ti,ab,kw. [Emergency/trauma services]	
23	or/14-22 [critical care set]	Critical/acute care
24	early diagnosis/ or (early adj2 (alert* or diagno* or detect* or warning*)).ti,ab,kw. [early dx/detection set]	Early diagnosis
25	patient acuity/ or "severity of illness index"/ or apache/ or early warning score/ or karnofsky performance status/ or organ dysfunction scores/ or simplified acute physiology score/	
26	((patient* or inpatient* or in-patient*or clinical or illness*) adj2 (acuit* or severity)).ti,ab,kw.	
27	vital signs/ or blood pressure/ or body temperature/ or heart rate/ or respiratory rate/	
28	("vital sign*" or "blood pressure*" or "diastolic pressure*" or "systolic pressure*" or "blood gas" or capnogra* or ("carbon dioxide" or CO2) adj2 (measurement* or monitoring)) or breathing or "cardiac output*" or "oxygen saturation*" or oximetr* or oximeter* or PtcO2 or TcPCO2 or pulse or "heart rate*" or "respiratory rate*" or "respiratory insufficien*" or respiration or "body temperature*" or fever or chill or chills or AVPU or "alert* voice* pain* unresponsive").ti,ab,kw.	
29	("urinary output" or "oxygen saturation" or "breathing difficul*" or "blood pressure*" or temperature or ECG or EKG or electrocardiogra* or "pulse oximetry" or telemetry).ti,ab,kw.	
30	or/25-29 [patient acuity/vital signs set]	Patient Acuity / Vital Signs
31	respiratory distress syndrome/ or respiratory insufficiency/ or acidosis, respiratory/ or airway obstruction/ or nasal obstruction/ or granuloma, laryngeal/ or hantavirus pulmonary syndrome/ or hypoventilation/ or obesity hypoventilation syndrome/ or brief, resolved, unexplained event/ or positive-pressure respiration, intrinsic/ or respiratory paralysis/ or acute lung injury/ or transfusion-related acute lung injury/ or ventilator-induced lung injury/ or bronchopulmonary dysplasia/ [respiratory failure/acute lung injury subject terms]	
32	((((respiratory or respiration) adj2 (arrest or deficiency or distress or disturbance or failure or insufficiency)) or (ARDS and (respirat* or lung or pulmonary)) or "lung shock").ti,ab,kw. or "lung injury".ti.	
33	or/31-32 [Respiratory failure set - subject/keyword]	Respiratory Failure
34	heart arrest/ or death, sudden, cardiac/ or karoshi death/ or heart failure/ or cardio-renal syndrome/ or dyspnea, paroxysmal/	

	or edema, cardiac/ or heart failure, diastolic/ or heart failure, systolic/ [heart failure subject terms]	
35	((cardiac or cardiopulmonary or heart) adj2 (arrest or infarct* or failure)) or asystole).ti,ab,kw. [heart failure keywords]	
36	or/34-35 [Heart failure set - subject/keywords]	Heart failure
37	shock/ or multiple organ failure/ or shock, cardiogenic/ or shock, hemorrhagic/ or shock, surgical/ or shock, traumatic/ or systemic inflammatory response syndrome/ or cytokine release syndrome/ or shock, septic/ [shock subject terms]	
38	(shock or "organ failure*" or "cardiovascular collapse" or "circulatory collapse" or "systemic inflammatory response syndrome*").ti,ab,kw. [shock keywords]	
39	sepsis/ or bacteremia/ or endotoxemia/ or hemorrhagic septicemia/ or candidemia/ [sepsis subject terms]	
40	(sepsis or septic or septicemia* or pyemia* or pyaemia* or "blood poison*" or "bloodstream infection*").ti,ab,kw. [sepsis keywords]	
41	or/37-40 [shock or sepsis set - subject/keywords]	Sepsis / Shock
42	acute kidney injury/ or kidney tubular necrosis, acute/ or liver failure, acute/ or acute-on-chronic liver failure/ or massive hepatic necrosis/ [acute kidney/liver subject terms]	
43	(acute adj2 (kidney or renal or liver or hepatic)).ti,ab,kw. [acute kidney/liver keywords]	
44	or/42-43 [acute kidney or liver set - subject/keywords]	Acute Kidney, Liver Failure/injuries
45	Hemorrhage/ or (hemorrhag* or bleeding).ti,ab,kw. [hemorrhage set - subject/keywords]	Hemorrhage
46	((heart or cardiac or nerve* or nervous or neuro*) adj1 acute) or ((heart or cardiac or nerve* or nervous or neuro*) adj2 ("adverse event*" or "serious event*"))).ti,ab,kw. [Acute CV/NS disease keywords 2]	Acute Cardiovascular or Nervous System event
48	or/31-46 [Acute conditions set]	Acute conditions
49	hospitalization/ or "length of stay"/ or patient readmission/ or patient transfer/	
50	(hospital or hospitals or hospitaliz* or hospitalis* or in-hospital* or "in hospital*" or inpatient* or in-patient*).ti,ab.	
51	("length of stay*" or length-of-stay* or "patient readmission*" or "hospital readmission*" or "patient transfer*").ti,ab,kw.	
52	exp Hospitals/	
53	hospital units/ or clinical observation units/ or hemodialysis units, hospital/ or intensive care units/ or burn units/ or coronary care units/	

	or intensive care units, pediatric/ or intensive care units, neonatal/ or recovery room/ or respiratory care units/ or nursing stations/ or quick diagnosis units/	
54	Hospital Medicine/	
55	Hospital Mortality/ or ((hospital* or in-hospital* or "in hospital" or in-house or inpatient* or patient*) adj2 (mortalit* or survival)).ti,ab,kw. [hospital mortality set]	
56	or/49-55 [Hospitals/hospitalization set - subject, keywords]	Hospital/hospitalization
57	Electronic Health Records/	
58	medical record linkage/ or medical records systems, computerized/ or health information exchange/	
59	((computer* or electronic or linkage) adj2 (health or medical) adj2 record?).ti,ab,kw.	
60	"Meaningful Use"/ or (meaningful adj1 "use?").ti,ab,kw.	
61	or/57-60 [EHR set 1]	
62	medical records/ or medical records, problem-oriented/	
63	information systems/ or big data/ or community networks/ or geographic information systems/ or health information systems/ or knowledge bases/ or biological ontologies/ or gene ontology/ or medical informatics computing/ or public health informatics/	
64	database management systems/ or data systems/	
65	Automation/	
66	((computer* or electronic or linkage or automated) adj2 (health or medical) adj2 record?).ti,ab,kw. [electronic medical record -EMR keyword terms]	
67	(62 and (or/63-65)) or 66 [EMR set]	
68	or/61,67 [EHR/EMR combined set]	EHR/EMR (electronic health record)
69	Decision Support Systems, Clinical/ or Decision Support Systems, Management/ or management information systems/ or decision support systems, management/ or hospital information systems/	
70	"decision making, computer-assisted"/ or decision support techniques/ or analytic hierarchy process/ or clinical decision rules/ or data interpretation, statistical/	
71	(CDS or CDSS).ti,ab. or ((clinical or hospital) adj4 ("decision support system?" or "information system?")).ti,ab,kw.	
72	((decision or decision-mak*) adj3 (aid or aids or analysis or analyses or model or models or support or technique*).ti,ab,kw.	
73	or/69-72 [CDSS set]	CDSS (clinical decision support system)

74	clinical decision-making/ or clinical reasoning/ or diagnosis, computer-assisted/ or decision support techniques/ or analytic hierarchy process/ or clinical decision rules/ or data interpretation, statistical/ or ("clinical decision-mak*" or "clinical decision mak*" or "clinical reasoning" or "clinical judgement*" or "clinical decision*" or "clinical predict*" or "alert fatigue" or "alarm fatigue" or (diagnosis adj2 ("computer assisted" or computer-assisted))).ti,ab,kw. [CDM - clinical decision making set -Mesh/keyword terms]	
75	algorithms/ or artificial intelligence/ or machine learning/ or deep learning/ or supervised machine learning/ or support vector machine/ or unsupervised machine learning/ or latent class analysis/ or decision theory/ or decision trees/ or neural networks, computer/	
76	computer heuristics/ or expert systems/ or fuzzy logic/ or machine learning/ or deep learning/ or supervised machine learning/ or support vector machine/ or unsupervised machine learning/ or natural language processing/ or neural networks, computer/	
77	(algorithm* or "deep learning" or deep-learning* or "machine learn*" or "machine intelligence*" or "artificial intelligence" or "ambient intelligence*" or ((artificial or automated or computation* or computer* or machine) adj2 (inference* or intelligence or learning or reasoning)) or "decision tree*" or "expert system*" or "fuzzy logic*" or "gradient boosting machine*" or heuristic* or hyperheuristic* or hyperheuristic* or metaheuristic* or meta-heuristic* or "multicriteria decision analysis" or "natural language processing" or "neural network*" or predict* or "reinforcement learning" or "simulated annealing" or "tabu search" or Xgboost or adaboost).ti,ab,kw. [keywords for AI or Machine Learning]	
78	Patient-Specific Modeling/ or (((patient-specific or "patient specific") adj2 modeling) or physiome*).ti,ab,kw.	
79	regression analysis/ or least-squares analysis/ or linear models/ or logistic models/ or proportional hazards models/ or spatial regression/ or (regression adj2 (analysis or analyses or diagnos* or statistical)).ti,ab,kw. or ((logistic or logit) adj2 (model* or regression)).ti,ab,kw.	
80	or/75-79 [AI-ML -- Artificial Intelligence-Machine Learning set]	AI-ML (Artificial Intelligence or Machine Learning)
81	artificial intelligence/ or machine learning/ or deep learning/ or supervised machine learning/ or unsupervised machine learning/ or ("deep learning" or deep-learning* or "machine learn*" or "machine intelligence*" or "artificial intelligence" or ((artificial or automated or computation* or computer* or machine) adj2 (inference* or	AI-ML 2 (focused set2 - Artificial Intelligence or Machine Learning)

	intelligence or learning or reasoning))).ti,ab,kf,kw. [AI-ML2 -- Artificial Intelligence-Machine Learning (focused- set 2]	
82	computing methodologies/ or exp computer systems/ or signal processing, computer-assisted/	
83	(computing or computer* or automate* or digital*).ti,ab,kw.	
84	or/82-83 [computing/computer set]	Computing
85	Data Mining/ or ("data mining" or data-mining or datamining).ti,ab,kw. [data mining terms]	Data mining
86	user-centered design/ or ergometry/	
87	("user centered*" or "user-centered" or usabilit*).ti,ab,kw.	
88	("human factor" or "human factors").ti,ab,kw.	
89	("computer user*" or (human* adj2 computer* adj2 interact*).ti,ab,kw.	
90	Universal Design/	
91	("Universal Design*" or "human centered design*" or "human-centered design*" or "design for all").ti,ab,kw.	
92	Ergonomics/ or Man-Machine Systems/	
93	("Clinical performance" or "clinical workflow*").ti,ab,kw.	
94	or/86-93 [user design/usability set]	User design / Usability
95	"attitude of health personnel"/ or alert fatigue, health personnel/ or practice patterns, nurses'/ or practice patterns, physicians'/ or ((attitude* or perception* or practice or pattern or patterns) adj3 (clinician* or doctor* or "hospital staff" or hospitalist* or "medical staff" or "nursing staff" or physician* or practitioner* or provider*).ti,ab,kw. [attitude/patterns - subject/keywords]	
96	medical staff, hospital/ or hospitalists/ or nursing staff, hospital/ or (clinician* or doctor* or "hospital staff" or hospitalist* or "medical staff" or "nursing staff" or physician* or practitioner* or provider* or "cardiac crash team*" or "code team*" or "medical emergency team*" or "rapid response team*").ti,ab,kw. [hospital staff, subject/keywords]	
97	or/95-96 [Clinicians-attitudes/hospital staff set]	Clinicians/response teams or Attitudes/pattern
98	exp Medical Informatics Computing/ or Informatics/ or Nursing Informatics/ or exp Medical Informatics Applications/ or exp Medical Informatics/	Informatics [Informatics MESH set]
99	("32166288" or "31135500" or "30278956" or "30121744" or "29450295" or "29435343" or "22067631" or "21227543" or "20959788").ui. [Exemplars]	Exemplar set
100	((alarm* or alert* or monitor* or surveillance or warning*) adj2 (automat* or clinical or continuous or early or electronic or real-time or	

	"real time")) or (early adj2 (alert* or diagno* or detect* or warning*))).ti. [early warn title set]	
101	(algorithm* or "deep learning" or deep-learning* or "machine learn*" or "machine intelligence*" or "artificial intelligence" or "ambient intelligence*").ti. [AI-ML title]	
102	((computer* or electronic or linkage) adj2 (health or medical) adj2 record?).ti. [EHR/EMR title]	
103	((acute* or catastrophic* or critical* or intensive*) adj2 (care or unit* or ward)).ti. [critical care -title]	
104	(hospital* or "length of stay*" or length-of-stay* or "patient readmission*" or "hospital readmission*" or "patient transfer*" or ((hospital* or in-hospital* or "in hospital" or in-house or inpatient* or patient*) adj2 (mortalit* or survival))).ti. [hospital title]	
105	predict*.ti.	
106	((or/100-101) and (or/103-104) and 105) or ("real-time electronic alerting".ti. and sniffer.ti,ab.) [titles: EarlyWarning/ML-AI + CritCare /Hospital + predict_ title set]	Titles set [to capture all exemplars]
107	(or/3,8,12) and 94 [Deterioration/monitoring/clinAlarm + user design/usability set]	[Deterioration/monitoring/clinAlarm + user design/usability set]
108	(or/3,8,12) and (or/73-74,80) and 97 and (or/23,48,56) and 12 [Deterioration/monitoring/clinAlarm + AI-ML/CDSS/CDM + Clinicians + CriticalCare/AcuteConditions/Hospital + risk/predict set]	[Deterioration/monitoring/clinAlarm + AI-ML/CDSS/CDM + Clinicians + CriticalCare/AcuteConditions/Hospital + risk/predict set]
109	(or/3,8,12) and 24 and (or/23,48) and (or/68,73,80) [Deterioration/monitoring/clinAlarm + early Dx +Crit care/Acute Conditions + EHR/CDDS/AI-ML]	[Deterioration/monitoring/clinAlarm + early Dx +Crit care/Acute Conditions + EHR/CDDS/AI-ML set]
110	or/106-109 [title set / usability set / clinicians set / early dx - Combo group 1]	
111	limit 110 to yr="2009 - 2021" [Combo group set 1]	[Combo group set 1]
112	(or/3,8) and 12 and 13 and (or/23,48) and (or/73-74,80) [Deterioration/monitoring/ + clinical alarms + risk/predict + Crit care/Acute Conditions + CDSS/CDM/AI-ML set]	Deterioration/monitoring/ + clinical alarms + risk/predict + Crit care/Acute Conditions + CDSS/CDM/AI-ML set]
113	3 and (or/73-74) and (or/68,80-81,85,98) [Deterioat + CDSS/CDM + EHR/AI-ML/Computing/DataMiing/MedInformatics]	[Deterioration + CDSS/CDM + EHR/AI-

		ML/Computing/DataMining/MedInformatics set]
114	3 and (or/12,24) and 80 [Deterioration + Clin alarms/EarlyDx + AI-ML]	[Deterioration + Clin alarms/EarlyDx + AI-ML set]
115	3 and (or/68,73) and 80 [Deterioat + CDSS/EHR + AI/ML]	[Deterioration + CDSS/EHR + AI/ML set]
116	3 and 73 and (assessment* or evaluation* or effectiveness or efficacy or feasibility or questionnaire* or survey* or validation).ti,ab,kf,kw. [Deterioat + CDSS + Assessment]	[Deterioration + CDSS + Assessment set]
117	(and/8,23-24) and (assessment* or evaluation* or effectiveness or efficacy or feasibility or questionnaire* or survey* or validation).ti,ab,kf,kw. [Monitoring + Early Dx + CritCare + Assessment]	[Monitoring + Early Dx + CritCare + Assessment set]
118	8 and (or/12,24) and 13 and (or/23,48,56) and 80 and (assessment* or evaluation* or effectiveness or efficacy or feasibility or questionnaire* or survey* or validation).ti,ab,kf,kw. [Monitoring/ + Clin alarms/EarlyDx + Risk/predict + Crit care/acute conditions/Hospital + AI-ML + Assessment]	[Monitoring/ + Clin alarms/EarlyDx + Risk/predict + Crit care/acute conditions/Hospital + AI-ML + Assessment set]
119	12 and 48 and (or/23,56) and (or/68,73,80) and (assessment* or evaluation* or effectiveness or efficacy or feasibility or questionnaire* or survey* or validation).ti,ab,kf,kw. [clin alarms + Crit care/Acute Conditions/Hospital + EHR/CDDS/AI-ML + Assessment]	[Clin alarms + Crit care/Acute Conditions/Hospital + EHR/CDDS/AI-ML + Assessment set]
120	or/112-119 [Combo group 2]	
121	limit 120 to yr="2009 - 2021" [Combo group set 2]	[Combo group set 2]
122	or/111,121 [Final set, Combo group sets 1 or 2]	[Final set, Combo group sets 1 or 2]
123	or/99,122 [Final set finds exemplars]	