

# APPENDIX 1: Literature Search Strategies

| Guide to Search Syntax |   |
|------------------------|---|
| exp                    | Explodes the subject heading to retrieve the search term plus all narrower (more specific) terms (OVID).  |
| /                      | All subheadings for a subject heading are included in the search (OVID).  |
| *term                  | Focuses the search to a particular subject heading, e.g. *emergency medical services (OVID).  |
| \$                     | Truncation symbol - searches for variations of a word (e.g. crowd\$ searches for crowd, crowded, crowds, crowding) (OVID).  |
| *                      | Truncation symbol - searches for variations of a word (e.g. crowd* searches for crowd, crowded, crowds, crowding). (Cochrane Library - Wiley InterScience®; EBSCOhost; ISI Web of KnowledgeSM; ProQuest; CSA Illumina). |
| .ti,ab.                | Searches in record title and abstract (OVID).   |
| .mp.                   | Searches in the title, abstract, and subject heading fields (OVID).   |
| TS=                    | Searches for a particular topic (ISI Web of KnowledgeSM).   |
| DE                     | Searches for subject headings and author-supplied keywords describing an article (EBSCOhost).   |
| ZU                     | Searches for subject headings (EBSCOhost).  |
| SU                     | Searches for articles about a specific subject (ProQuest).  |
| DE=                    | Searches for subject terms (also called descriptors) (CSA Illumina).  |
| kw:                    | Searches for keywords (CSA Illumina).   |
| adj, #                 | Searches for keywords “adjacent” to each other within a specified number (OVID).  |
| next                   | Searches for keywords that appear next to each other (Cochrane Library - Wiley InterScience®).  |
| “ “                    | Searches for phrases, e.g. “fast track” (OVID; EBSCOhost; ProQuest; SIGLE).   |
| .pt.                   | Searches for a particular publication type (OVID).  |
| MeSH                   | Searches for a Medical Subject Heading from the National Library of Medicine’s controlled vocabulary (Cochrane Library - Wiley InterScience®; NLM Gateway).   |
| MESH NOMAP             | A MeSH term is searched as an exact MeSH phrase (NLM Gateway).  |

| Database  | Search Strategies  |
|---|--|
| MEDLINE®  | 1. exp CROWDING/<br>2. crowd\$.ti,ab.<br>3. overcrowd\$.ti,ab.   |
| EBM Reviews -<br>Cochrane Central<br>Register of<br>Controlled Trials | 4. gridlock\$.ti,ab.<br>5. volume\$.ti,ab.<br>6. load\$.ti,ab.<br>7. board\$.ti,ab.<br>8. overload\$.ti,ab.  |
| Ovid MEDLINE®<br>In-Process & Other<br>Non-Indexed<br>Citations       | 9. "access block\$".ti,ab.<br>10. (throughput OR through-put).ti,ab.<br>11. warehous\$.ti,ab.<br>12. ("left without being seen" OR "leave\$ without being seen" OR |

| Database                                    | Search Strategies   |
|---|---|
| HealthSTAR/Ovid<br>Healthstar<br><br>(OVID) | lwbs).ti,ab.<br>13. (ambulance\$ adj2 diver\$).ti,ab.<br>14. "fast track\$".ti,ab.<br>15. (wait\$ adj2 time\$).ti,ab.<br>16. delay\$.ti,ab.<br>17. ("patient flow\$" OR "flow of patient\$").ti,ab.<br>18. defer\$.ti,ab.<br>19. (esi OR "emergency severity index").ti,ab.<br>20. *Health Services Misuse/<br>21. (misuse\$ OR overutili\$).ti,ab.<br>22. ((nonurgent OR non-urgent OR inappropriate OR nonacute) adj5 (patient\$ OR visit\$ OR use\$ OR care OR problem\$ OR attend\$)).ti,ab.<br>23. ("length of stay\$" OR los).mp.<br>24. (length adj2 stay\$).ti,ab.<br>25. (acuit\$ OR complexit\$).ti,ab.<br>26. (capacit\$ OR occupanc\$).ti,ab.<br>27. (lama OR (leave\$ adj4 ("medical advice" OR treatment\$)) OR (left adj4 ("medical advice" OR treatment\$))).ti,ab.<br>28. OR/1-27<br>29. *emergency medical services/ OR *emergency medical service communication systems/ OR *emergency service, hospital/ OR *trauma centers/ OR *emergency services, psychiatric/ OR *"transportation of patients"/ OR *ambulances/ OR *air ambulances/ OR *triage/<br>30. (triage\$ OR "emergency medical service\$ communication\$ system\$" OR "trauma center\$" OR "trauma centre\$" OR "tranport\$ adj2 patient\$").mp.<br>31. (emergenc\$ adj2 (medical\$ OR health OR hospital\$ OR psychiatric) adj2 service\$).mp.<br>32. (("a and e" OR "a & e" OR a&e) adj1 (service\$ OR department\$)).ti,ab.<br>33. ((emergenc\$ OR emerg OR accident\$ OR casualt\$) adj2 (service\$ OR department\$ OR room\$ OR centre\$ OR center\$ OR unit\$)).ti,ab.<br>34. ("acute care" OR "emergency care").mp.<br>35. (emergicenter\$ OR emergicentre\$).mp.<br>36. (((prehospital OR pre-hospital) adj2 emergenc\$ adj2 care\$) OR ("prehospital care" OR "pre-hospital care")).mp.<br>37. (emergenc\$ adj2 (outpatient\$ OR out-patient\$) adj2 unit\$).mp.<br>38. ((ems OR ed OR er) AND emergenc\$).mp.<br>39. ("observation unit\$" OR "observation area\$" OR "holding unit\$" OR "holding area\$").ti,ab.<br>40. "Canadian Triage & Acuity Scale".mp.<br>41. ambulance\$.ti,ab.<br>42. OR/29-41<br>43. 28 AND 42<br>44. remove duplicates from 43<br>Results:<br>- Medline: 8777<br>- EBM Reviews - Cochrane Central Register of Controlled Trials: 529<br>- Ovid MEDLINE® In-Process & Other Non-Indexed Citations: 195 |

| Database             | Search Strategies  |
|----------------------|--|
| EMBASE<br><br>(OVID) | <p>- HealthSTAR/Ovid Healthstar: 8869</p> <ol style="list-style-type: none"> <li>1. exp CROWDING/</li> <li>2. crowd\$.ti,ab.</li> <li>3. overcrowd\$.ti,ab.</li> <li>4. gridlock\$.ti,ab.</li> <li>5. volume\$.ti,ab.</li> <li>6. load\$.ti,ab.</li> <li>7. board\$.ti,ab.</li> <li>8. overload\$.ti,ab.</li> <li>9. "access block\$".ti,ab.</li> <li>10. (throughput or through-put).ti,ab.</li> <li>11. warehous\$.ti,ab.</li> <li>12. ("left without being seen" or "leave\$ without being seen" or lwbs).ti,ab.</li> <li>13. (ambulance\$ adj2 diver\$).ti,ab.</li> <li>14. "fast track\$".ti,ab.</li> <li>15. (wait\$ adj2 time\$).ti,ab.</li> <li>16. delay\$.ti,ab.</li> <li>17. ("patient flow\$" or "flow of patient\$").ti,ab.</li> <li>18. defer\$.ti,ab.</li> <li>19. (esi or "emergency severity index").ti,ab.</li> <li>20. (misuse\$ or overutili\$).ti,ab.</li> <li>21. ((nonurgent or non-urgent or inappropriate or nonacute) adj5 (patient\$ or visit\$ or use\$ or care or problem\$ or attend\$)).ti,ab.</li> <li>22. ("length of stay\$" or los).mp.</li> <li>23. (length adj2 stay\$).ti,ab.</li> <li>24. (acuit\$ or complexit\$).ti,ab.</li> <li>25. (capacit\$ or occupanc\$).ti,ab.</li> <li>26. (lama or (leave\$ adj4 ("medical advice" or treatment\$)) or (left adj4 ("medical advice" or treatment\$))).ti,ab.</li> <li>27. or/1-26</li> <li>28. exp emergency health service/ or exp patient transport/ or exp AMBULANCE/ or exp emergency ward/</li> <li>29. (triage\$ or "emergenc\$ adj2 service\$ adj2 communication\$" or "trauma center\$" or "trauma centre\$" or "transport\$ adj2 patient\$").mp.</li> <li>30. (emergenc\$ adj2 (medical\$ or health or hospital\$ or psychiatric) adj2 service\$).mp.</li> <li>31. ((emergenc\$ or emerg or accident\$ or casualt\$) adj2 (service\$ or department\$ or room\$ or centre\$ or center\$ or unit\$)).ti,ab.</li> <li>32. (("a and e" or "a &amp; e" or a&amp;e) adj1 (service\$ or department\$)).ti,ab.</li> <li>33. ("acute care" or "emergency care").mp.</li> <li>34. (emergicenter\$ or emergicentre\$).mp.</li> <li>35. (((prehospital or pre-hospital) adj2 emergenc\$ adj2 care\$) or ("prehospital care" or "pre-hospital care")).mp.</li> <li>36. (emergenc\$ adj2 (outpatient\$ or out-patient\$) adj2 unit\$).mp.</li> <li>37. ((ems or ed or er) and emergenc\$).mp.</li> <li>38. ("observation unit\$" or "observation area\$" or "holding unit\$" or "holding area\$").ti,ab.</li> </ol> |

| Database              | Search Strategies  |
|-----------------------|--|
|                       | 39. "Canadian Triage & Acuity Scale".mp.<br>40. (ambulance\$ or "emergency car\$" or "emergency vehicle\$").ti,ab.<br>41. or/28-40<br>42. 27 and 41<br>43. remove duplicates from 42<br>Results: 6066  |
| CINAHL®<br><br>(OVID) | 1. crowd\$.ti,ab.<br>2. overcrowd\$.ti,ab.<br>3. gridlock\$.ti,ab.<br>4. volume\$.ti,ab.<br>5. load\$.ti,ab.<br>6. board\$.ti,ab.<br>7. overload\$.ti,ab.<br>8. "access block\$.ti,ab.<br>9. (throughput or through-put).ti,ab.<br>10. warehous\$.ti,ab.<br>11. ("left without being seen" or "leave\$ without being seen" or lwbs).ti,ab.<br>12. (ambulance\$ adj2 diver\$).ti,ab.<br>13. "fast track\$".ti,ab.<br>14. (wait\$ adj2 time\$).ti,ab.<br>15. delay\$.ti,ab.<br>16. ("patient flow\$" or "flow of patient\$").ti,ab.<br>17. defer\$.ti,ab.<br>18. (esi or "emergency severity index").ti,ab.<br>19. *Health Services Misuse/<br>20. (misuse\$ or overutili\$).ti,ab.<br>21. ((nonurgent or non-urgent or inappropriate or nonacute) adj5 (patient\$ or visit\$ or use\$ or care or problem\$ or attend\$)).ti,ab.<br>22. ("length of stay\$" or los).mp.<br>23. (length adj2 stay\$).ti,ab.<br>24. (acuit\$ or complexit\$).ti,ab.<br>25. (capacit\$ or occupanc\$).ti,ab.<br>26. (lama or (leave\$ adj4 ("medical advice" or treatment\$)) or (left adj4 ("medical advice" or treatment\$))).ti,ab.<br>27. or/1-26<br>28. exp Emergency Service/ or exp trauma centers/ or exp TRIAGE/ or exp Emergency Care/ or exp "Transportation of Patients"/ or exp Ambulances/ or exp Prehospital Care/<br>29. (triage\$ or "emergency medical service\$ communication\$ system\$" or "trauma center\$" or "trauma centre\$" or "transport\$ adj2 patient\$").mp.<br>30. (emergenc\$ adj2 (medical\$ or health or hospital\$ or psychiatric) adj2 service\$).mp.<br>31. ((emergenc\$ or emerg or accident\$ or casualt\$) adj2 (service\$ or department\$ or room\$ or centre\$ or center\$ or unit\$)).ti,ab.<br>32. (("a and e" or "a & e" or a&e) adj1 (service\$ or department\$)).ti,ab.<br>33. ("acute care" or "emergency care").mp.<br>34. (emergicenter\$ or emergicentre\$).mp. |

| Database                         | Search Strategies  |
|----------------------------------|--|
|                                  | <p>35. (((prehospital or pre-hospital) adj2 emergenc\$ adj2 care\$) or ("prehospital care" or "pre-hospital care")).mp.<br/> 36. (emergenc\$ adj2 (outpatient\$ or out-patient\$) adj2 unit\$).mp.<br/> 37. ((ems or ed or er) and emergenc\$).mp.<br/> 38. ("observation unit\$" or "observation area\$" or "holding unit\$" or "holding area\$").ti,ab.<br/> 39. "Canadian Triage &amp; Acuity Scale".mp.<br/> 40. ambulance\$.ti,ab.<br/> 41. or/28-40<br/> 42. 27 and 41<br/> 43. remove duplicates from 42<br/> Results: 2770</p>   |
| <p>PsycINFO®<br/><br/>(OVID)</p> | <p>1. exp CROWDING/<br/> 2. crowd\$.ti,ab.<br/> 3. overcrowd\$.ti,ab.<br/> 4. gridlock\$.ti,ab.<br/> 5. volume\$.ti,ab.<br/> 6. load\$.ti,ab.<br/> 7. board\$.ti,ab.<br/> 8. overload\$.ti,ab.<br/> 9. "access block\$".ti,ab.<br/> 10. (throughput or through-put).ti,ab.<br/> 11. warehous\$.ti,ab.<br/> 12. ("left without being seen" or "leave\$ without being seen" or lwbs).ti,ab.<br/> 13. (ambulance\$ adj2 diver\$).ti,ab.<br/> 14. "fast track\$".ti,ab.<br/> 15. (wait\$ adj2 time\$).ti,ab.<br/> 16. delay\$.ti,ab.<br/> 17. ("patient flow\$" or "flow of patient\$").ti,ab.<br/> 18. defer\$.ti,ab.<br/> 19. (esi or "emergency severity index").ti,ab.<br/> 20. (misuse\$ or overutili\$).ti,ab.<br/> 21. ((nonurgent or non-urgent or inappropriate or nonacute) adj5 (patient\$ or visit\$ or use\$ or care or problem\$ or attend\$)).ti,ab.<br/> 22. *treatment duration/<br/> 23. ((treatment\$ adj2 duration) or ("length of stay\$" or los)).mp.<br/> 24. (length adj2 stay\$).ti,ab.<br/> 25. (acuit\$ or complexit\$).ti,ab.<br/> 26. (capacit\$ or occupanc\$).ti,ab.<br/> 27. (lama or (leave\$ adj4 ("medical advice" or treatment\$)) or (left adj4 ("medical advice" or treatment\$))).ti,ab.<br/> 28. or/1-27<br/> 29. exp EMERGENCY SERVICES/<br/> 30. (triage\$ or "emergency medical service\$ communication\$ system\$" or "trauma center\$" or "trauma centre\$" or "transport\$ adj2 patient\$").mp.<br/> 31. (emergenc\$ adj2 (medical\$ or health or hospital\$ or psychiatric) adj2 service\$).mp.</p> |

| Database  | Search Strategies  |
|---|--|
|   | <p>32. (("a and e" or "a &amp; e" or a&amp;e) adj1 (service\$ or department\$)).ti,ab.<br/> 33. ((emergenc\$ or emerg or accident\$ or casualt\$) adj2 (service\$ or department\$ or room\$ or centre\$ or center\$ or unit\$)).ti,ab.<br/> 34. ("acute care" or "emergency care").mp.<br/> 35. (emergicenter\$ or emergicentre\$).mp.<br/> 36. (((prehospital or pre-hospital) adj2 emergenc\$ adj2 care\$) or ("prehospital care" or "pre-hospital care")).mp.<br/> 37. (emergenc\$ adj2 (outpatient\$ or out-patient\$) adj2 unit\$).mp.<br/> 38. ((ems or ed or er) and emergenc\$).mp.<br/> 39. ("observation unit\$" or "observation area\$" or "holding unit\$" or "holding area\$").ti,ab.<br/> 40. "Canadian Triage &amp; Acuity Scale".mp.<br/> 41. ambulance\$.ti,ab.<br/> 42. or/29-41<br/> 43. 28 and 42<br/> 44. remove duplicates from 43<br/> Results: 532</p> |
| <p>The Cochrane Database of Systematic Reviews</p> <p>Database of Abstracts of Reviews of Effects (DARE)</p> <p>Health technology assessment database (HTA)</p> <p>NHS Economic evaluation database (NHS EED)</p> <p>(all via The Cochrane Library - Wiley InterScience®)</p> | <p>EMERGENCY MEDICAL SERVICES explode all trees (MeSH) or AMBULANCES single term (MeSH)</p> <p>And</p> <p>CROWDING single term (MeSH) or (crowd* or overcrowd* or volume* or load* or throughput* or delay* or (access next block*) or (ambulance next diver*) or (fast next track) or (wait* next time*) or delay* or (patient next flow*) or (flow next patient) or (flow next patients) or overutili* or nonurgent or (length next stay) or acuit* or capacit* or occupanc* gridlock* or board* or overload* or warehous* or (emergency next severity next index) or misuse*)</p> <p>Results: 144</p>   |
| <p>Science Citation Index Expanded™</p> <p>Social Sciences Citation Index</p> <p>(ISI Web of KnowledgeSM)</p>   | <p>TS=crowd* OR TS=overload* OR TS=emergency department* volume* OR TS=gridlock OR TS=access block* OR TS=leave without treatment</p> <p>AND</p> <p>TS=emergency medical service* OR TS=emergency service* OR TS=trauma center* OR TS=ambulance* OR TS=triage OR TS=prehospital care OR TS=acute care OR TS=emergency care OR TS=hospital emergenc* OR TS=emergency-department* OR TS=public hospital* emergenc*</p>   |

| Database                                   | Search Strategies  |
|--|--|
| Academic Search Premier<br>(EBSCOhost)     | Results: 69<br>(((DE "EMERGENCY medical services" OR DE "AMBULANCE service" OR DE "EMERGENCY medical personnel" OR DE "HOSPITALS -- Emergency service" OR DE "PEDIATRIC emergency services" OR DE "POISON control centers" OR DE "TRIAGE (Medicine)") or (DE "EMERGENCY medical services -- Communication systems" OR DE "PERSONAL emergency response systems") or (DE "EMERGENCY medical services -- Utilization")) or (DE "TRAUMA centers" OR DE "PEDIATRIC trauma centers")) or (DE "AMBULANCES" OR DE "AIRPLANE ambulances" OR DE "HELICOPTER ambulances" OR DE "HOSPITAL trains" OR DE "INTENSIVE care units, Mobile")) or (DE "TRIAGE (Medicine)")<br><br>AND<br><br>(Crowd* or gridlock or load* or "Access block" or overcrowd* or volume* or "ambulance divers*" or "fast track" or "wait* time*" or misuse* or overutili* or nonurgent or "length of stay" or acuit* or complexit* or capacit* or occupanc* or "patient flow*" or "flow of patient*" or "left without being seen" or "leav* without being seen")<br>Results: 410 |
| Social Sciences Abstracts<br>(EBSCOhost)   | (DE "Emergency medical services") or (DE "Emergency medical services-- Conferences") or (DE "Triage (Medicine)") or ambulance*<br><br>AND<br><br>crowd* or overcrowd* or "fast track" or "wait* time*" or "patient flow*" or "flow of patient*" or "length of stay*" or misuse* or overutili* or nonurgent or volume* or "access block*" or "ambulance diver*"           Results: 0  |
| ABI/Inform®<br>CBCA Business<br>(ProQuest) | SU(emergency services or ambulance services or triage) AND (crowd* or overcrowd* or gridlock* or volume* or load* or board* or overload* or "Access block*" or throughput or through-put or warehous* or "left without being seen" or "leav* without being seen" or lwbs or "ambulance divers*" or "fast track" or "wait* time*" or delay* or "patient flow*" or "flow of patient*" or esi or "emergency severity index" or misuse* or overutili* or nonurgent or "length of stay" or acuit* or complexit* or capacit* or occupanc* or lama or "leave* against medical advice" or "left against medical advice" or "leave* without medical treatment" or "left without medical treatment")<br>Results: 171   |
| Business Source Premier<br>(EBSCOhost)     | (((ZU "EMERGENCY MEDICAL SERVICES") or (ZU "EMERGENCY MEDICAL SERVICES -- COMMUNICATION SYSTEMS")) or (ZU "TRIAGE (MEDICINE)") or (ZU "TRAUMA CENTERS")) or (ZU "AMBULANCE SERVICE") or (DE "HOSPITALS -- Emergency service")  |

| Database  | Search Strategies   |
|---|---|
|   | <p>and</p> <p>(crowd* or overcrowd* or gridlock* or volume* or load* or board* or overload* or "Access block*" or throughput or through-put or warehous* or "left without being seen" or "leav* without being seen" or lwbs or "ambulance divers*" or "fast track" or "wait* time*" or delay* or "patient flow*" or "flow of patient*" or esi or "emergency severity index" or misuse* or overutili* or nonurgent or "length of stay" or acuit* or complexit* or capac* or occupanc* or lama or "leave* against medical advice" or "left against medical advice" or "leave* without medical treatment" or "left without medical treatment")</p> <p>Results: 123</p>   |
| INFORMS Online  | <p>Emergency</p> <p>Results: 55</p>   |
| <p>PAIS (Public Affairs Information Service) International (CSA Illumina)</p> | <p>(de="Emergency services" or "Emergency medical services") and (kw=overcrowding or kw=crowd* or kw=overcrowd* or kw=gridlock* or kw=volume* or kw=load* or kw=board* or kw=overload* or kw="Access block*" or kw=throughput or kw=through-put or kw=warehous* or kw="left without being seen" or kw="leav* without being seen" or kw=lwbs or kw="ambulance divers*" or kw="fast track" or kw="wait* time*" or kw=delay* or kw="patient flow*" or kw=esi or kw="emergency severity index" or kw=misuse* or kw=overutili* or kw=nonurgent or kw="length of stay" or kw=acuit* or kw=complexit* or kw=capac* or kw=occupanc* or kw=lama or kw="leave* against medical advice" or kw="left against medical advice" or kw="leave* without medical treatment" or kw="left without medical treatment")</p> <p>Results: 8</p> |
| SIGLE   | <p>"EMERGENCY SERVICES" OR "EMERGENCY SERVICES PROVISION" OR "AMBULANCE SERVICE" OR "AMBULANCE SERVICES" OR AMBULANCES OR AMBULANCE OR TRIAGE</p> <p>Results: 0</p>   |
| GrayLIT Network   | <p>Overcrowding or emergency department</p> <p>Results: 3</p>   |
| <p>Dissertation Abstracts (ProQuest)</p>                                      | <p>Overcrowding and emergency<br/>Patient flow<br/>Waiting time and emergency</p> <p>Results: 20</p>  |
| <p>NLM Gateway (search for Meeting Abstracts)</p>                             | <p>Emergency Service, Hospital[MESH] OR Emergency Medical Services[MESH_NOMAP] OR Triage[MESH] OR Ambulances[MESH]</p> <p>Results: 107 Meeting Abstracts</p>  |

## APPENDIX 2: Electronic Databases Searched

| Database  | Platform               | Coverage of Search                            | Date of Search  |
|---|------------------------|---|---|
| MEDLINE®  | Ovid Version: rel9.1.0 | 1966 to November Week 1 2004                  | November 15, 2004 (updates on December 1, 2004 and December 09, 2004) |
| EBM Reviews - Cochrane Central Register of Controlled Trials                | Ovid Version: rel9.1.0 | 3rd Quarter 2004 (Coverage goes back to 1950) | November 15, 2004 (updates on December 1, 2004 and December 09, 2004) |
| Ovid MEDLINE® In-Process & Other Non-Indexed Citations                      | Ovid Version: rel9.1.0 | 1966 to November 14, 2004.                    | November 15, 2004 (updates on December 1, 2004 and December 09, 2004) |
| EMBASE  | Ovid Version: rel9.1.0 | 1988 to 2004 Week 46                          | November 15, 2004 (updates on December 1, 2004 and December 09, 2004) |
| CINAHL® (Cumulative Index to Nursing & Allied Health Literature)            | Ovid Version: rel9.1.0 | 1982 to November Week 1 2004                  | November 16, 2004 (updates on December 1, 2004 and December 09, 2004) |
| HealthSTAR/Ovid Healthstar  | Ovid Version: rel9.1.0 | 1975 to October 2004                          | November 16, 2004 (updates on December 1, 2004 and December 09, 2004) |
| PsycINFO®   | Ovid Version: rel9.1.0 | 1872 to October Week 4 2004                   | November 16, 2004 (updates on December 1, 2004 and December 09, 2004) |
| Science Citation Index Expanded™ (via Web of Science®)                      | ISI Web of KnowledgeSM | 1945 to November 2004                         | November 16, 2004   |
| Database of Abstracts of Reviews of Effects (DARE) via The Cochrane Library | Wiley InterScience®    | 1995 to December 2004                         | December 10, 2004   |

| Database   | Platform   | Coverage of Search  | Date of Search    |
|--|--|---|-------------------|
| Health Technology Assessment Database (HTA) via The Cochrane Library   | Wiley InterScience®  | 1995 to December 2004   | December 10, 2004 |
| NHS Economic Evaluation Database (NHS EED) via the Cochrane Library  | Wiley InterScience®  | 1995 to December 2004   | December 10, 2004 |
| Academic Search Premier  | EBSCOhost  | Coverage varies by journal - some full text journals date back as far as 1965 or the first issue published. | November 16, 2004 |
| Social Sciences Abstracts  | EBSCOhost  | 1984 to December 2004   | December 14, 2004 |
| ABI/Inform®  | ProQuest®  | 1971 to December 2004   | December 07, 2004 |
| CBCA Business  | ProQuest®  | 1980 to December 2004   | December 07, 2004 |
| Business Source Premier  | EBSCOhost  | 1922 to December 2004   | December 07, 2004 |
| PAIS (Public Affairs Information Service) International  | CSA Illumina   | 1972 to December 2004   | December 09, 2004 |
| INFORMS Online   | Institute for Operations Research and the Management Sciences<br>( <a href="http://www.informs.org/">http://www.informs.org/</a> )                                     | December 2004   | December 09, 2004 |
| SIGLE (System for Information on Grey Literature in Europe) (please note: this database no longer exists as of 2005) | FIZ Karlsruhe – Version Interhost 3000   | 1980 to November 2004   | November 17, 2004 |
| GrayLit Network  | U.S. Department of Energy's (DOE) Office of Scientific and Technical Information (OSTI)<br>( <a href="http://www.osti.gov/graylit/">http://www.osti.gov/graylit/</a> ) | November 2004   | November 17, 2004 |

| Database               | Platform  | Coverage of Search    | Date of Search    |
|------------------------|---|-----------------------|-------------------|
| Dissertation Abstracts | ProQuest®   | 1980 to November 2004 | November 17, 2004 |
| NLM Gateway            | U.S. National Library of Medicine - <a href="http://gateway.nlm.nih.gov/gw/Cmd">http://gateway.nlm.nih.gov/gw/Cmd</a> | 1950 to November 2004 | November 17, 2004 |

## APPENDIX 3: Form for Inclusion and Exclusion of Studies

| <b>Measures to document overcrowding in emergency departments</b>  |   |  |                          |
|--|---|--|--------------------------|
| Article identification:  | Reviewer's initials:  | Date:     /     /2005<br>(dd) (mm)                   |                          |
| <b>1. Topic</b><br>a) Is primary issue in this study related to emergency department overcrowding? Study must refer to overcrowding or one of its synonyms in introductory or methods section. Exclude studies that have as their primary focus any of the following: workload, satisfaction, quality of care, utilization.     Yes <input type="checkbox"/> No <input type="checkbox"/> Unsure <input type="checkbox"/> |   |  |                          |
| b) Is the report primary research?     Yes <input type="checkbox"/> No <input type="checkbox"/> Unsure <input type="checkbox"/>  |   |  |                          |
| <b>2. Design</b><br>Does study satisfy any of the following designs?     Yes <input type="checkbox"/> No <input type="checkbox"/> Unsure <input type="checkbox"/>  |   |  |                          |
| RCT  | <input type="checkbox"/>  | Case series  | <input type="checkbox"/> |
| Quasi-randomized trial, or CCT   | <input type="checkbox"/>  | Cross-sectional study                                | <input type="checkbox"/> |
| Cohort study   | <input type="checkbox"/>  | Computer or mathematical model                       | <input type="checkbox"/> |
| Case-control study   | <input type="checkbox"/>  | Delphi technique or qualitative study                | <input type="checkbox"/> |
| Before-and-after study   | <input type="checkbox"/>  | Other: _____   | <input type="checkbox"/> |
| <b>3. Variables</b><br>Does study measure events related to ED overcrowding? These events can be any one or combination of ED factors (waiting times), hospital-related but non-ED factors (access block), factors external to hospital (ambulance diversion).     Yes <input type="checkbox"/> No <input type="checkbox"/> Unsure <input type="checkbox"/>  |   |  |                          |
| <b>4. Final Decision</b>   |   |  |                          |
| INCLUDE<br>(meets all criteria) <input type="checkbox"/>   | EXCLUDE<br>(fails to meet at least one of the criteria) <input type="checkbox"/>                      | UNSURE<br>(needs more data) <input type="checkbox"/> |                          |
| Require English translation <input type="checkbox"/>   | Study provides useful background information Yes <input type="checkbox"/> No <input type="checkbox"/> |  |                          |
| If disagreement between reviewers, final outcome:<br><br>INCLUDED <input type="checkbox"/> (meets all criteria)                      EXCLUDED <input type="checkbox"/>   |   |  |                          |

## APPENDIX 4: Data Extraction Form

|  |  |                                       |                                  |
|--|--|---------------------------------------|----------------------------------|
| Article identification                                 | Reviewer's initials:                   | Verifier's initials:                  |                                  |
| Author:  | Year:                                  | Country:                              |                                  |
| Number of study centres                                | Single centre <input type="checkbox"/> | Multicentre <input type="checkbox"/>  | Unsure <input type="checkbox"/>  |
| Study objective  |  |                                       |                                  |
| Operational definition of ED overcrowding              |  |                                       |                                  |
| Study design   |  |                                       |                                  |
| RCT  | <input type="checkbox"/>               | Case series                           | <input type="checkbox"/>         |
| Quasi-randomized trial, or CCT                         | <input type="checkbox"/>               | Cross-sectional study                 | <input type="checkbox"/>         |
| Cohort study   | <input type="checkbox"/>               | Computer or mathematical model        | <input type="checkbox"/>         |
| Case-control study                                     | <input type="checkbox"/>               | Delphi technique or qualitative study | <input type="checkbox"/>         |
| Before-and-after study                                 | <input type="checkbox"/>               | Other: _____                          | <input type="checkbox"/>         |
| Overall comments on study                              |  |                                       |                                  |
| Name of measure  |  |                                       |                                  |
| Description of measure                                 |  |                                       |                                  |
| Category of measure                                    |  |                                       |                                  |
| Input <input type="checkbox"/>                         | Throughput <input type="checkbox"/>    | Output <input type="checkbox"/>       | System <input type="checkbox"/>  |
| Purpose of measure                                     |  |                                       |                                  |
| Descriptive or discriminative <input type="checkbox"/> | Predictive <input type="checkbox"/>    | Evaluative <input type="checkbox"/>   | Unclear <input type="checkbox"/> |
| Additional comments                                    |  |                                       |                                  |

## APPENDIX 5: Excluded Articles and Reason for Exclusion

### Not primary research (214)

1. Adams JG, Biros MH. The endangered safety net: establishing a measure of control. *Acad Emerg Med* 2001; 8(11):1013-15.
2. Alderman C. Beat the clock. *Nurs Stand* 2000; 14(24):12-3.
3. Alexander M. The focus is on patients' clinical needs and distress. *BMJ* 2003; 326(7402):1332.
4. Allred RJ, Ewer S. Improved emergency department patient flow: five years of experience with a scribe system. *Ann Emerg Med* 1983; 12(3):162-3.
5. American Academy of Pediatrics Committee on Pediatric Emergency Medicine. Overcrowding crisis in our nation's emergency departments: is our safety net unraveling? *Pediatrics* 2004; 114(3):878-88.
6. American College of Emergency Physicians. Hospital and emergency department overcrowding. *Ann Emerg Med* 1990; 19(3):336.
7. American College of Emergency Physicians. Boarding of admitted and intensive care patients in the emergency department. *Ann Emerg Med* 2001; 38(4):484-5.
8. Angelucci P, Stolee J. Far out. *Nurs Manage* 2001; 32(4):45-6.
9. Access management quarterly: use creative thinking to streamline ED patient flow: program WOWs hospital ED. *Hosp Case Manag* 2004; 12(5):75-7.
10. ACEP (American College of Emergency Physicians) suggests ways to reduce emergency room overcrowding. *Hosp Guest Relations Rep* 1989; 4(10):5.
11. Action needed to address excessive waiting times in A&E in Britain. *Qld Nurse* 2000; 19(2):20.
12. Add-on room helps trauma center up case volume, shorten waits. *OR Manager* 2003; 19(11):12.
13. Ambulance diversion. *Ann Emerg Med* 1999; 34(1):124.
14. Ambulatory care quarterly: three strategies to reduce overcrowding and gridlock. *Hosp Case Manag* 2004; 12(9):139-40.
15. Are you putting patients in danger? You need to reduce your diversion rates. *ED Manag* 2001; 13(2):13-5.
16. Bed-der than ever. *Health Manag Technol* 2003; 24(3):58.
17. Benchmarking success. You can reduce delays for lab tests by 60%. *ED Manag* 2001;

- 13(5):56-7.
18. Better use of nurses reduces waiting times. *Aust Nurs J* 2001; 9(4):35.
  19. Boston medical groups find placing facilitator in ED helps avert avoidable hospital stays. *Sr Care Manag* 2003; 6(11):145-8.
  20. California ED benchmarks show capacity keeping pace with higher demand. *Capitation Rates Data* 2004; 9(5):53-5.
  21. Capacity improvements reduce ED diversions. *Healthc Financ Manage* 2004; 58(4):26.
  22. CDC report shows ER visits jump 20% since 1992; metro hospitals tend to see larger volume of visits. *Health Care Strateg Manage* 2003; 21(7):5.
  23. CDC reports sharp increase in ED visits: numbers blamed partly on boarding of patients. *ED Manag* 2003; 15(8):94.
  24. Anonymous. 'Code Purple' mode relieves ED bottlenecks. *ED Manag* 2000; 12(12):139-42.
  25. Common cause. *Hosp Health Netw* 2004; 78(4):22-4.
  26. Coordinated ambulance diversion improves care. *Emerg Med Serv* 2004; 33(1):29.
  27. Crowding causes ER costs to rise. *Mater Manag Health Care* 2003; 12(12):5.
  28. Cut delays by an hour with triage protocols. *ED Nursing* 2003; 6(9):104-5.
  29. Data from ED patient tracking system help identify X-ray cycle time improvements. *Data Strateg Benchmarks* 1998; 2(1):4-8.
  30. Discharge planning advisor - the update for improving continuity of care. DP, CM skills may stem bed-capacity problems: crowded EDs said to be draining resources. *Hosp Case Manag* 2002; 10(7):107-9.
  31. ED benchmarking success: make these changes to cut delays, diversion hours: triage protocols and teams yield dramatic results. *ED Manag* 2003; 15(6):64-5.
  32. ED overcrowding leading to more diversions. *Healthc Financ Manage* 2002; 56(5):21.
  33. ED pledge: see doc in 30 minutes or visit is free. *Healthc Benchmarks* 1999; 6(2):18-9.
  34. ED sees 50% reduction in time from triage to ED bed. *ED Manag* 2004; 16(10):114-5.
  35. Anonymous. EDs are shouldering an increasingly heavy load. *AHA News* 2004; 40(17):8.
  36. Anonymous. Eliminating triage a very bad idea. *J Emerg Nurs* 2000; 26(3):205.
  37. Emergency department pathways slash LOS and testing costs. *Hosp Case Manag* 1994; 2(7):112-6.

38. ER emergency. *Yankee* 2002; 66(9):18.
39. Fast-track protocol targets high-cost, high-volume cases. *Health Care Cost Reengineering Rep* 1998; 3(5):65-71.
40. Forrest General Hospital re-engineers emergency department to increase throughput. *Inside Ambul Care* 1996; 3(9):5-6.
41. 'Gridlock page' helps clear crowded ED. *ED Manag* 2004; 16(3):32-3.
42. Here are trends you must be ready for. *ED Manag* 2001; 13(5):52-4.
43. Hospital emergency department diversion rates slow down. *Qual Lett Healthc Lead* 2004; 16(4):14-6.
44. Hospital focus. Patient satisfaction: these novel strategies decrease ED delays. *RN* 1998; 61(9):24BB, 24DD, 24FF-GG.
45. Hospitals in crisis: overcrowding and staff shortages lead to new recommendations. *Am J Nurs* 2002; 102(7):20.
46. Hospitals look for answers to help stem ED crowding. *AHA News* 2003; 39(12):7.
47. How can you keep average wait less than 1 hour? VHA shares its strategies. *ED Manag* 2004; 16(4):37-9.
48. How to cut delays on the front end. *ED Manag* 2000; 12(3):29-30.
49. Anonymous. Identify best practices to improve patient flow in your ED. *ED Manag* 1999; 11(2):13-6.
50. Is your ED overcrowded? Reduce risks with these aggressive tactics. *ED Manag* 1999; 11(7):73-5.
51. It's not business as usual: you can fight patient surges with an aggressive plan. *ED Manag* 2003; 15(11):121-4.
52. Measures to deal with emergency department overcrowding. *Ann Emerg Med* 1990; 19(8):944-45.
53. Media campaign educates public on ED overcrowding. *ED Manag* 2004; 16(4):40-2.
54. Novel strategies decrease ED delays. *ED Manag* 1997; 9(5):49-54.
55. Novel strategies decrease ED delays: success stories to improve front-line performance emergency departments. *Patient Focus Care Satisf* 1998; 6(3):35-40.
56. Novel strategies to handle nonemergent ED visits. *ED Manag* 2003; 15(2):21-2.
57. Nurse clinicians are key to fast-track program. *ED Manag* 1995; 7(7):78-9.

58. Nurse X-ray requests reduce waiting times. *Aust Nurs J* 2002; 10(4):26.
59. Outpatient connection: survey: overcrowded ERs mean more wait time. *Healthc Purch News* 2002; 26(6):24.
60. Overcrowded emergency departments increase time ambulances are out of service. *PA Times* 2004; 27(1):4-8.
61. Patient- and staff-friendly Express Admission Unit enhances efficiency. *COR Clin Excell* 2002; 3(7):1-3.
62. Patient-flow fixes ease ED crowding. *OR Manager* 2004; 20(5):5-7.
63. Placing facilitator in ED cuts avoidable hospital stays. *Clin Resour Manag* 2001; 2(2):17-20.
64. Reduce 'boarder' patients in your department. *ED Manag* 2001; 13(2):17-9.
65. Reduce risks of patients who leave too soon. *ED Manag* 2001; 13(11):125-6.
66. Report puts spotlight on inpatient holds: the No. 1 reason for ED overcrowding. *ED Manag* 2003; 15(6):61-3.
67. Reports say diversion on the rise: use technology to overhaul patient flow. *ED Manag* 2002; 14(3):25-7.
68. Researchers identify measures of workflow that may help to explain and manage emergency department overcrowding. *Res Activities* 2004; (282):10-1.
69. ROI in the ED. *Health Manag Technol* 2003; 24(11):46.
70. Scheme cuts A&E waiting times for many. *Nurs Stand* 2003; 17(44):5.
71. Some ways to pinpoint ED delays and reduce them. *RN* 1974; 37(11):OR7.
72. Streaming patients improves waiting times. *Aust Nurs J* 2002; 9(11):18.
73. Study may relieve hospital emergency department overcrowding. *Occup Health Saf* 2004; 73(8):12.
74. Study offers solutions for bottlenecks: treat and move patients in record time. *ED Manag* 2000; 12(3):25-9.
75. Survey: overcrowded emergency departments leading to more diversions, longer wait times. *Health Care Strateg Manage* 2002; 20(7):7.
76. Survey: overcrowded ERs mean more wait time. *Healthc Purch News* 2002; 26(6):24.
77. System launches 3-level plan to cut ED crowding. *Healthc Benchmarks Qual Improv* 2004; 11(1):6-7.

78. Take tip from restaurants to ease waits, ED advises. *ED Manag* 2004; 16(1):4-5.
79. Teamwork helps cut ED wait times. *Healthc Benchmarks* 2000; 7(4):40-1.
80. These novel strategies decrease ED delays. *RN* 1998; 61(9):24BB.
81. Three strategies to reduce overcrowding and gridlock. *ED Manag* 2004; 16(7):78-80.
82. Time studies identify interventions to boost patient flow in your ED. *ED Manag* 1999; 11(12):133-7.
83. Tool helps bypass the emergency room. *Mark Health Serv* 2003; 23(4):9.
84. The top five. Try a mix of strategies to prevent deadly delays to treatment in overloaded and understaffed EDs. *Jt Comm Benchmark* 2002; 4(10):11.
85. Tracking system helps ED slash wait times, staff costs. *Data Strateg Benchmarks* 1998; 2(8):113-6.
86. Trauma teams to the rescue. *USA Today Magazine* 2003; 132(2701):14-5.
87. Trusts claim massive cuts to A&E waiting times. *Nurs Stand* 2003; 99(14):5.
88. Tullamore A&E overcrowding reaches Dublin proportions. *World Ir Nurs* 2004; 12(5):12.
89. U.S. hospitals have become greatly overcrowded, resulting in overloaded ERs and diverted ambulances. *Res Activities* 2003; (277):21.
90. UK scheme ditches triage and reduces waiting times. *Aust Nurs J* 2002; 10(3):14.
91. Unique collaboration targets delays: learn from the impressive results of 31 EDs. *ED Manag* 1998; 10(10):109-16.
92. Use protocol to send inpatient holds upstairs. *ED Manag* 2003; 15(4):43-4.
93. Using technology to improve patient flow. *RN* 67(7):28ac2-4.
94. Waiting for care. *Am Nurse* 2002; 34(3):5.
95. Want to improve quality of care and ease the burdens on your physicians? *ED Manag* 2004; 16(5):49-52.
96. Diversion: guideline statements on prehospital diversion. In: *Red Book*. Phoenix (AZ): Arizona Emergency Medical Systems, Inc.; 2000. Available: <http://www.aems.org/PDF/Chapt8For.pdf>.
97. Ashby RH. Responses to access block in Australia: Queensland. *Med J Aust* 2003; 178(3):107-8.
98. Australasian College for Emergency Medicine. Access block and overcrowding in

emergency departments. West Melbourne: The College; 2004. Available from:  
[http://www.acem.org.au/media/Access\\_Block1.pdf](http://www.acem.org.au/media/Access_Block1.pdf).

99. Australasian College for Emergency Medicine. The relationship between emergency department overcrowding and alternative after-hours GP services. West Melbourne: The College; 2004. Available from:  
[http://www.medeserv.com.au/acem/open/documents/after\\_hoursgp.pdf](http://www.medeserv.com.au/acem/open/documents/after_hoursgp.pdf).
100. Barishansky RM, O'Connor KE, Eckstein M, Chan LS. The effect of emergency department crowding on ambulance availability. *Ann Emerg Med* 2004; 44(3):280-1.
101. Barker J, Ashton N, Williams C *et al*. On target in A&E. *Nurs Manage* 2004; 11(7):19-22.
102. Barthell EN. Opening the ED doors. *Health Forum J* 2003; 46(3):45.
103. Barzoloski-O'Connor B. Creatively combating the ED overcrowding crunch. *Nurs Spectr (Wash D C)* 2002; 12(2):16-7.
104. Bazzoli GJ, Brewster LR, Liu G, Kuo S. Does US hospital capacity need to be expanded? *Health Aff* 2003; 22(6):40.
105. Beales J. Management. Innovation in accident and emergency management: establishing a nurse practitioner-run minor injuries/primary care unit. *Accid Emerg Nurs* 1997; 5(2):71-5.
106. Benitez MA. Hong Kong tackles health-service overload by charging emergency fee. *Lancet* 2002; 360(9347):1757.
107. Bennett RM. State of emergency. *Ind Eng* 2003; 35(5):50.
108. Botvin JD. Baptist Memorial addresses national shortage of emergency room space. Campaign by Memphis, Tenn., system points to minor med facilities. *Profiles Healthc Mark* 2004; 20(1):1.
109. Brewster LR, Rudell LS, Lesser CS. Emergency room diversions: a symptom of hospitals under stress. *Issue Brief Cent Stud Health Syst Change* 2001; (38):1-4.
110. Canadian Association of Emergency Physicians, National Emergency Nurses Affiliation. Joint position statement: access to acute care in the setting of emergency department overcrowding. *CJEM* 2003; 5(2):81-6.
111. Callahan CD, Griffen DL. Advanced statistics: applying statistical process control techniques to emergency medicine: a primer for providers. *Acad Emerg Med* 2003; 10(8):883-90.
112. Cameron PA, Campbell DA. Responses to access block in Australia: Royal Melbourne Hospital. *Med J Aust* 2003; 178(3):109-10.
113. Campbell SG, Sinclair DE. Strategies for managing a busy emergency department. *CJEM* 2004; 6(4):271-6.
114. Canet Gonzalez R, Formiga Perez F, Pujol Farriols R. Chaos at the emergency service:

- several solutions. *Med Clin (Barc)* 1992; 99(10):397.
115. Cardello DM. Implementation of a one-hour fast-track service: one hospital's experience. *J Emerg Nurs.* 1992; 18(3):239-43.
  116. Coid J, Crome P. Bed blocking in Bromley. *Br Med J (Clin Res Ed)* 1986; 292(6530):1253-6.
  117. Cooke MW, Higgins J, Bridge P. *A&E: the present state.* Birmingham: Emergency Medicine Research Group, Universities of Warwick and Birmingham; 2000.
  118. Crowding Resources Task Force, American College of Emergency Physicians. *Responding to emergency department crowding: a guidebook for chapters.* Dallas (TX): The College; 2002.
  119. Denny CJ, Steinhart BD, Yu R. Improving physician flow and efficiency in the emergency department. *CJEM* 2003; 5(4):271-4.
  120. Derlet RW, Richards JR. Overcrowding in the nation's emergency departments: complex causes and disturbing effects. *Ann Emerg Med* 2000; 35(1):63-8.
  121. Duffin C. Three overcrowded A&E units 'compromise safety'. *Nurs Stand* 2002; 6(29):6.
  122. Eamer D. Bed management: very model of a modern major general. *Health Serv J* 1999; 109(5681):24-5.
  123. Eggertson L. ED problems result of bed shortages, doctors contend. *CMAJ* 2004; 170(11):1653-4.
  124. Espinosa J. Use real-time data to reduce delays. *ED Manag* 1999; 11(1):9-11.
  125. Fatovich DM. Responses to access block in Australia: Royal Perth Hospital. *Med J Aust* 2003; 178(3):108-9.
  126. Fatovich DM, Roberts PA, Cunningham PA. Access block: problems and progress. *Med J Aust* 2003; 178(10):527-8.
  127. Feldman JA. A call to action on emergency department overload and diversion. *Acad Emerg Med* 2002; 9(8):866-7.
  128. Fields WW. Emergency care in California: robust capacity or busted access? *Health Aff* 2004; W143.
  129. Frank IC. ED crowding and diversion: strategies and concerns from across the United States. *J Emerg Nurs* 2001; 27(6):559-65.
  130. Franzblau DC. A new look at urgent care centers and fast tracks. *Inside Ambul Care* 1997; 3(11):4-6.
  131. Gallagher EJ, Lynn SG. The etiology of medical gridlock: causes of emergency department overcrowding in New York city. *J Emerg Med* 1990; 8(6):785-90.

132. Garza M. EMS news: Providers cope with overcrowded ED diversions. *JEMS* 2001; 26(3):16-7.
133. Garza M. Last word: Memphis just says 'no!' to ambulance diversion. *JEMS* 2004; 29(1):130.
134. Geraci E. The overcrowding of the emergency room of hospitals. *G Ital Cardiol* 1993; 23(3):219.
135. Greene J. If you can't stem the tide, try diverting a trickle. *Mod Healthc* 1992; 22(15):49.
136. Greene M, Houlihan J, Mian S. Emergency department (ED) overcrowding and diversion study. West Palm Beach (FL): Health Care District of Palm Beach County; s.n. Available from:  
[http://www.hcdpbc.org/other\\_programs/PDF/Emergency%20Department\\_final\\_board.pdf](http://www.hcdpbc.org/other_programs/PDF/Emergency%20Department_final_board.pdf).
137. Hagland MM. ED overcrowding spurs interest in quality and credentialing issues. *Hospitals* 1991; 65(14):33-6.
138. Hammett RJ, Robinson BG. Responses to access block in Australia: Royal North Shore Hospital. *Med J Aust* 2003; 178(3):105-7.
139. Haraden C, Resar R. Patient flow in hospitals: understanding and controlling it better. *Front Health Serv Manage* 2004; 20(4):3-15.
140. Haugh R. Rethinking our pressure-packed emergency departments. *Hosp Health Netw* 2003; 77(6):66.
141. Haugh R. A true picture of what ails your emergency department. *Hosp Health Netw* 2004; 78(6):66-70.
142. Hobbs GD. Current and future issues in emergency medicine. Technology early warning system: white paper. Marriottsville (MD): Bon Secours Health System, Inc.; 2002.
143. Hodges J. Smoothing the flow. *Hosp Health Netw* 2003; 77(7): 14.
144. Honeycutt LJ. Avoiding a crowd in the ED. *Nurs Manage* 2004; 35(10):47.
145. Hwang U, Concato J. Care in the emergency department: how crowded is overcrowded? *Acad Emerg Med* 2004; 11(10):1097-101.
146. Isaacman DJ, Poirier MP, King RB, Shaw K, Adams JG. ED overcrowding: meeting many needs. *Pediatr Emerg Care* 2004; 20(10):710-6.
147. Jensen J. Going with the flow. Tracking system helps Midwest hospital streamline patient flow and lower emergency room divert rate. *Health Manag Technol* 2003; 24(12):43-5.
148. Karpel M. Improving emergency department flow: eliminating ED inefficiencies reduces patient wait times. *Healthc Exec* 2004; 19(1):40-1.
149. Karpel M, Williams M. Developing a fast track program. *J Ambul Care Mark* 1988; 2(2):35-

- 48.
150. Karpel MS. Benchmarking facilitates process improvement in the emergency department. *Healthc Financ Manage* 2000; 54(5):54-9.
  151. Kelly J. Emergency diversions: ED teamwork: good way to overcome emergency department overcrowding and diversions. *Hosp Health Netw* 2002; 76(3):30-2.
  152. Kleinpell RM. Area hospitals take on ED overcrowding. *Nurs Spectr (Gt Chic Ne Ill Nw Indiana Ed)* 2002; 15(2):8.
  153. Kmietowicz Z. Waiting times in British casualty departments remain too long. *BMJ* 1999; 318(7180):351.
  154. Koles B. Overcrowded emergency rooms: do we need more capacity or fewer patients? Is there a lack of access to primary care services? And, what is the real cost of ED utilization. Washington (DC): Council on Healthcare Economics and Policy; 2002.
  155. Krug SE. Overcrowding crisis in our nation's emergency departments: is our safety net unraveling? *Pediatrics* 2004; 114(3):878-88.
  156. Lancaster-Bowie L. Fast-tracking of non-urgent emergency department presentations utilising a CNS advanced practitioner position. *Aust Emerg Nurs J* 1998; 1(4):4-11.
  157. Larkin H. Tonight in the ED: sneezers, no bleeders. *Hosp Health Netw* 2004; 78(1):22-4.
  158. Lees L, Ferreday J. The role of a flow coordinator in an emergency assessment unit. *Nurs Times* 2003; 99(32):32-4.
  159. Leifer D, Scott G. Overcrowding crisis leads to historic decision. *Nurs Stand* 1997; 11(44):12.
  160. Lett D. Manitoba to fast-track less critical emergency patients. *CMAJ* 2004; 171(9):1031.
  161. Liple N. A&E set for waiting time 'exclusions'. *Emerg Nurse* 2003; 11(3):3.
  162. Liple N. Game over: A&E department waiting times. *Emerg Nurse* 2003; 10(9):5.
  163. Liple N. Testing times. *Emerg Nurse* 2004; 12(3):5.
  164. Litvak E, Long MC, Copper AB, McManus ML. Emergency department diversion: causes and solutions. *Acad Emerg Med* 2001; 8(11):1108-10.
  165. Lynn SG, Kellermann AL. Critical decision making: managing the emergency department in an overcrowded hospital. *Ann Emerg Med* 1991; 20(3):287-92.
  166. Manos D. Design & construction--ER on the fast track. *Hosp Health Netw* 2000; 74(7):24, 26.
  167. Martenson S, Rosen J, Jones C, Mangrum D. Managers forum: eliminating ambulance

- diversions: senior administration is considering a policy that eliminates the possibility of ambulance diversion when the department is overwhelmed with critical patients. How are other emergency departments dealing with this need? *J Emerg Nurs* 1999; 25(3):226-7.
168. McCabe JB. Emergency department overcrowding: a national crisis. *Acad Med* 2001; 76(7):672-4.
  169. McCaig LF, Burt CW. National Hospital Ambulatory Medical Care Survey: 2002 emergency department summary. *Adv Data* 2004; 340:1-34.
  170. McLendon MH. What causes long waits, diversions and overcrowding in hospital EDs? *Health Care Strateg Manage* 2001; 19(5):12-4.
  171. McManus M. Emergency department overcrowding in Massachusetts: making room in our hospitals. *Issue Brief (Mass Health Policy Forum)* 2001; (12):1-38.
  172. Michan Dona A, Cobo Mora J, Amado Aragonés A, Juárez Alonso S. Chaos in emergency departments: some solutions. *Med Clin (Barc)* 1991; 97(20):796.
  173. Michelson AS, Frank IC. What are emergency departments doing to minimize ambulance diversions? *J Emerg Nurs* 1994; 20(3):235-6.
  174. Miller MJ, Ferrin DM, Messer MG. Fixing the emergency department: a transformational journey with EDSIM. In: Ingalls RG, Rossetti MD, Smith JS, Peters BA, editors. *Proceedings of the 2004 Winter Simulation Conference*; 2004 Dec 5-8.
  175. Morgan L. Nurse-run clinic lightens the load for crowded ED patients. *NurseWeek (California Statewide Edition)* 1996; 9(21):6.
  176. Morris Z. A&E scheme drops triage and reduces waiting times. *Nurs Stand* 2002; 16(37):9.
  177. Morrissey J. The edge: triage for the ER: Miami Children's Hospital finds extra space, extra time to ease overcrowding, curb delays in providing treatment. *Mod Healthc* 2003; 33(25):65-6, 68, 75.
  178. Neville L, Rowland RS. Short stay unit solves emergency overcrowding. *Dimens Health Serv* 1983; 60(2):26.
  179. New South Wales Audit Office. *Performance audit report: hospital emergency departments: delivering services to patients*. Sydney: The Office; 2000.
  180. Emergency Services Collaborative, NHS Modernisation Agency. *Improvements in emergency care [Case studies vol 1]*. London: The Agency; 2002. Available from: <http://www.modern.nhs.uk/esc/8237/Case%20Studies%20%20Low%20Res%20.pdf>.
  181. Emergency Services Collaborative, NHS Modernisation Agency. *Improvements in emergency care [Case studies vol 2]*. London: The Agency; 2002. Available from: [http://www.modern.nhs.uk/esc/7902/Emer\\_case\\_study.pdf](http://www.modern.nhs.uk/esc/7902/Emer_case_study.pdf).

182. Nordberg M. Closed for business: overcrowding in the ED. *Emerg Med Serv*. 2001 Jul;30(7):31-4, 38, 41-4
183. Nordberg M. Overcrowding: the ED's newest predicament. *Emerg Med Serv* 1990; 19(4):33.
184. Access issues at NSW public hospitals: key strategies. North Sydney: NSW Department of Health; 2003. Available from: [http://www.health.nsw.gov.au/pubs/a/pdf/access\\_issues.pdf](http://www.health.nsw.gov.au/pubs/a/pdf/access_issues.pdf).
185. Parish C. Better patient care flow cuts trolley waits in A&E units. *Nurs Stand*. 2001; 15(49):6.
186. Parker C. Study shows 10-year drop in EDs, while use jumped 27% in California. *AHA News* 2002; 38(12):3.
187. Parker P. Move care to a higher level with emergency systems. *Nurs Manage* 2004; 35(9):82.
188. Pavlovich-Danis SJ. ED waiting times a pain? *Nurs Spectr (Fla Ed)* 2003; 16(6):8.
189. Pinchok D. New hospital seeks to increase ED patient volume. *J Emerg Nurs* 2004; 30(3):202.
190. Pinker S. Latest ER crisis hit communities large and small. *CMAJ* 2000; 162(4):559 .
191. Richardson DB. Reducing patient time in the emergency department. *Med J Aust* 2003; 179(10):516-7.
192. Riepen D, van Carrapiett D, Anderson J III, Kindley D, Rose L. Managers forum: decreasing length of stay: what strategies to shorten the patients' length of stay (LOS) in the emergency department are working for others? *J Emerg Nurs* 1999; 25(1):45-50.
193. Ritter V, Pierce B, Pound JL. Managers ask and answer. Improving patient flow through triage. *J Emerg Nurs* 1998; 24(2):183-4.
194. Romanelli N. We put ED patients on the fast track. *RN* 1992; 55(7):17-8.
195. Romano M. It's a whole new ER. Forget the crowded waiting room. In fact, forget the waiting room altogether. *Mod Healthc* 2003; 33(39):30.
196. Society for Academic Emergency Medicine. ED and crowding: research agenda and recent solutions. SAEM Luncheon Session. Society for Academic Emergency Medicine Annual Meeting; 2003 May 29-June 1; Boston (MA). Available from: <http://www.saem.org/meetings/03handouts/asplin.pdf>. 2003 Annual Meeting
197. Sandrick K. Moving patients through: three top-performing emergency departments demonstrate how it's done. *Strateg Healthc Excell* 1999; 12(7):1-7.
198. Schafermeyer RW, Asplin BR. Hospital and emergency department crowding in the United States. *Emerg Med* 2003; 15(1):22-7.
199. Schull MJ. Sex, SARS, and the Holy Grail: what each tells us about overcrowding. *Emerg*

Med J 2003; 20(5):400-1.

200. Shactman D, Altman SH. Utilization and overcrowding of hospital emergency departments. Unpublished. 2002.
201. Sibbald B. Emergency doctors, nurses prescribe cure for overcrowding. CMAJ 2001; 164(7):1034.
202. Siegel B. Triage for overcrowding: hospitals should fix the emergency department problems they can control. Mod Healthc 2003; 33(27):24.
203. Sinreich D, Marmor Y. A STAFFING emergency. Ind Eng 2004; 36(5):38.
204. Spooner MH. Long waits in NHS casualty departments. CMAJ 2002; 167(3):292.
205. Use of hospital emergency rooms, 2003. Ottawa: Statistics Canada; 2004.
206. Stephens N. One emergency department's responses to the increasingly complex challenges of patient care at century's change. J Emerg Nurs 2000; 26(4):318-28.
207. Stokes B. Overcrowding in A&E sparks call for inquiry. Nurs Stand 1998; 12(37):9.
208. Tapanes T, Steele R. The team approach to emergency department overcrowding. J Emerg Nurs 1994; 20(5):405-6.
209. Wallen TK. Designing a fast track system. Surg Serv Manage 1999; 5(2):37-8.
210. Wilson L. Turning down the volume. More commitment to primary care has helped reduce ER visits. Mod Healthc 2004; Suppl:12.
211. Wilson MJ, Nguyen K. Bursting at the seams: improving patient flow to help America's emergency departments. Washington (DC): George Washington University Medical Center, School of Public Health and Health Services; 2004.
212. Winnipeg Regional Health Authority. Emergency care task force: report to the Honourable David Chomiak, Minister of Health, Province of Manitoba. Winnipeg: The Authority; 2004.
213. Yoon P. Emergency department fast-track system. Edmonton: Alberta Heritage Foundation for Medical Research (AHFMR); 2003.
214. Zibulewsky J, Spaite DW. Academic department expansion: yesterday's news: rapid process redesign in a university-based emergency department: decreasing waiting time intervals and improving patient satisfaction. Ann Emerg Med 2002; 40(4):440-2.

#### **Not related to ED overcrowding (194)**

1. Abba AA, Wani BA, Rahmatullah RA, Khalil MZ, Kumo AM, Ghonaim MA. Door to needle time in administering thrombolytic therapy for acute myocardial infarction. Saudi Med J 2003; 24(4):361-4.

2. Abernathy III JH, McGwin Jr G, Acker III JE, Rue III LW. Impact of a voluntary trauma system on mortality, length of stay, and cost at a level I trauma center. *Am Surg* 2002; 68(2):182.
3. Abramowitz S, Joy SA, Yurt RW. Emergency room visit time: changes over a 16-year period. *N Y State J Med* 1989; 89(8):446-9.
4. Acid S, de Campos LM, Fernandez-Luna JM, Rodriguez S, Rodriguez M, Salcedo L. A comparison of learning algorithms for Bayesian networks: a case study based on data from an emergency medical service. *Artif Intell Med* 2004; 30(3):215-32.
5. Afilalo J, Marinovich A, Afilalo M, Colacone A, Leger R, Unger B *et al.* Nonurgent emergency department (ED) visits: patient characteristics and barriers to primary care. *CJEM* 2003; 5(3).
6. Afilalo M, Lang E, Boivin JF. The impact of a standardized information system between the emergency department and the primary care network: effects on continuity and quality of care. Ottawa: Canadian Health Services Research Foundation; 2003.
7. Afilalo M, Lang E, Boivin JF, Leger B, Colacone A, Guguere C *et al.* Do electronic linkages between the ED and primary care physicians reduce resource utilization in the ED? Results of a randomized controlled trial. *CJEM* 2003; 5(3).
8. Aggarwal P, Wali JP, Ranganathan S, Kailash S, Kumar A, Mishra MC. Utility of an observation unit in the emergency department of a tertiary care hospital in India. *Eur J Emerg Med* 1995; 2(1):1-5.
9. Altman DF, Levitt L, Lewis F, Shaghoury C. A community-wide assessment of future trauma service demand and supply. *Abstr Book Assoc Health Serv Res Meet* 14:52-3.
10. Anderson HJ. Updated emergency departments stress improved access to care. *Hospitals* 1992; 66(18):34.
11. AMI team buckles down to improve outcomes. *Hosp Case Manag* 1998; 6(3):46-9.
12. Case management for uninsured cuts length of stay, readmissions: patients are encouraged to have a primary care home. *Hosp Case Manag* 2004; 12(8):113-5.
13. Creativity catches on with ED staff. *Healthc Benchmarks* 1999; 6(2):19-20.
14. Critical-care transport team improves care. *ED Manag* 2003; 15(1):6-7.
15. ED's paradigm shift cuts costs, improves quality. *Healthc Benchmarks* 1997; 4(5):65-6.
16. Foothills emergency: a look at length of stay. *Dimens Health Serv* 1984; 61(1):26-28.
17. Going to the dogs. *Nursing (Lond)* 1999; 29(9):62.
18. Increase capacity with chest pain accreditation. *ED Manag* 2004; 16(2):16-7.

19. New system brings all hospital databases to ED. *ED Manag* 1999; 11(9):104-5.
20. Patients can help with documentation. *ED Manag* 2000; 12(10):116-7.
21. Program cuts LOS, ED visits for kidney patients: nurses monitor members face to face. *Case Manag Advis* 2004; 15(8):90-2.
22. Toyota's tips drive dramatic ED improvements. *ED Manag* 2002; 14(11):125-6.
23. Want to drastically cut LWBS numbers? Try ice packs and adding a fast track. *ED Manag* 2003; 15(12):133-6.
24. Arendt KW, Sadosty AT, Weaver AL, Brent CR, Boie ET. The left-without-being-seen patients: what would keep them from leaving? *Ann Emerg Med* 2003; 42(3):317-23.
25. Bachtel J, Lyle CR. Information technology can improve healthcare quality. *Comput Healthc* 1992; 13(10):43.
26. Bagust A, Place M, Posnett JW. Dynamics of bed use in accommodating emergency admissions: stochastic simulation model. *BMJ* 1999; 319(7203):155-8.
27. Batal H, Tench J, McMillan S, Adams J, Mehler PS. Predicting patient visits to an urgent care clinic using calendar variables. *Acad Emerg Med* 2001; 8(1):48-53.
28. Beales J. Accident and emergency: a godsend for the East End. *Health Serv J* 1997; 107(5560):28-9.
29. Bearie BJ, Langdorf MI, Blasko BJ, Kohl A. Comparison of emergency patients' and emergency physicians' assessments of emergency medical conditions: prudent layperson Definition. *Acad Emerg Med* 2002; 9(5):540-1.
30. Bellini R, Brennan M. Zero waiting room time does not work when patients outnumber beds. *J Emerg Nurs* 2000; 26(5):408-9.
31. Berglin Blohm M, Nilsson G, Karlsson T, Herlitz J. The possibility of influencing components of hospital delay time within emergency departments among patients with ST-elevation in the initial electrocardiogram. *Eur J Emerg Med* 1998; 5(3):289-96.
32. Berman DA, Coleridge ST, McMurry TA. Computerized algorithm-directed triage in the emergency department. *Ann Emerg Med* 1989; 18(2):141-4.
33. Blizzard R. Does hospital size matter in the emergency room? *Gallup Poll Tuesday Briefing* 2004; 1-3.
34. Boes ME. A typology for establishing social work staffing patterns within an emergency room. *Crisis Interv Time-Limited Treat* 1997; 3(3):171-88.
35. Bond GR, Wiegand CB. Estimated use of a pediatric emergency department observation unit. *Ann Emerg Med* 1997; 29(6):739-42.

36. Booth AJ, Harrison CJ, Gardener GJ, Gray AJ. Waiting times and patient satisfaction in the accident and emergency department. *Arch Emerg Med* 1992; 9(2):162-8.
37. Boyack VJ, Bucknum AE. The Quick Response Team: a pilot project. *Soc Work Health Care* 1991; 16(2):55-68.
38. Brenner BE, Holmes TM, Simpson DD, Smith CW, Reese EA. Reducing specialty consultation times in the emergency department. *Acad Emerg Med* 2004; 11(5):463.
39. Bullard M, Holroyd B, Craig W, Klassen T, Yiannakoulias N, Johnson D. Patients who leave without being seen in the emergency department. 3. 2001.
40. Bullard M, Holroyd B, Craig W, Klassen T, Yiannakoulias N, Johnson D *et al*. Patients who leave without being seen in the emergency department. *Acad Emerg Med* 2001; 8(5):576-7.
41. Burns S, Wiegenstein JG. Patients, charts, and orders: keeping track. *Ann Emerg Med* 1980; 9(2):92-5.
42. Byrne G, Richardson M, Brunsdon J, Patel A. An evaluation of the care of patients with minor injuries in emergency settings. *Accid Emerg Nurs* 2000; 8(2):101-9.
43. California Health Care Foundation. California's emergency departments: system capacity and demand. Los Angeles: USC Center for Health Financing, Policy, and Management; 2002. Available from: <http://www.chcf.org/topics/view.cfm?itemID=19771>.
44. Cassidy-Smith T, Chiaccio M, Durana E, Scheets K, Baumann BM, Boudreaux ED. Improving patient satisfaction by information delivery: a controlled trial of two simple, cost-effective interventions. *Acad Emerg Med* 2004; 11(5):459.
45. Cassidy-Smith T, Lawler C, Perez R, Baumann BM, Boudreaux ED. The disconfirmation paradigm: how throughput times impact patient satisfaction in the emergency department. *Acad Emerg Med* 2004; 11(5).
46. Chan L, Kass LE. Impact of medical student preceptorship on ED patient throughput time. *Am J Emerg Med* 1999; 17(1):41-3.
47. Chan L, Reilly KM, Salluzzo RF. Variables that affect patient throughput times in an academic emergency department. *Am J Med Qual* 1997; 12(4):183-6.
48. Christenson J, Clarke T, Innes G, Anis A, McKnight D, Boychuk B *et al*. Does access to a STAT cardiology follow-up clinic reduce ED length of stay in patients with chest pain? *CJEM* 2002; 4(2).
49. Coats TJ, Michalis S. Mathematical modelling of patient flow through an accident and emergency department. *Emerg Med J* 2001; 18(3):190-2.
50. Cochard R, Allen K, Bettinger M *et al*. Implementation of a rapid treatment and short-stay unit. In: HIMSS '99: discover the synergy. Proceedings of the 1999 Annual HIMSS Conference, vol 4; 1999 Feb 21-25. Chicago: HIMSS; 1999.

51. Conrad L, Markovchick V, Mitchiner J, Cantrill SV. The role of an emergency department observation unit in the management of trauma patients. *J Emerg Med* 1985; 2(5):325-33.
52. Cornwell III EE, Chang DC, Phillips J, Campbell KA. Enhanced trauma program commitment at a level I trauma center: Effect on the process and outcome of care. *Arch Surg* 2003; 138(8):838-43.
53. Cowell VL, Ciraulo D, Gabram S, Lawrence D, Cortes V, Edwards T *et al.* Trauma 24-hour observation critical path. *J Trauma* 1998; 45(1):147-50.
54. Csepanyi A. The Hungarian model of an emergency admission and care department. *Ann Emerg Med* 1980; 9(7):364-7.
55. Dallos V, Mouzas GL. An evaluation of the functions of the short-stay observation ward in the accident and emergency department. *Br Med J (Clin Res Ed)* 1981; 282(6257):37-40.
56. Delgado CA, Fleisher GR. Radiology services in the pediatric emergency department. *Pediatr Emerg Care* 1995; 11(2):69-71.
57. Demers L, Lemieux V. La politique quebecoise de desengorgement des urgences. *Canadian Public Administration/Administration Publique Du Canada* 1998; 41(4):501-28.
58. Dershewitz RA, Paichel W. Patients who leave a pediatric emergency department without treatment. *Ann Emerg Med* 1986; 15(6):717-20.
59. Diehl AK, Morris MD, Mannis SA. Use of calendar and weather data to predict walk-in attendance. *South Med J* 1981; 74(6):709-12.
60. Docimo AB, Pronovost PJ, Davis RO, Concordia EB, Gabrish CM, Adessa MS *et al.* Using the online and offline change model to improve efficiency for fast-track patients in an emergency department. *Jt Comm J Qual Improv* 2000; 26(9):503-14.
61. Dong SL, Bullard MJ, Meurer DP, Blitz S, Colman I, Rowe BH. Emergency department triage: evaluating the validity of a computerized triage tool. *CJEM* 2004; 6(2).
62. Dos Santos LM, Stewart G, Rosenberg NM. Pediatric emergency department walk-outs. *Pediatr Emerg Care*. 1994; 10(2):76-8.
63. Edwards DH, Scott JC. Work load and medical staffing in an accident service. *Injury* 1971; 2(3):199-204.
64. Eliasoph H, Ashdown C. Development, testing and implementation of an emergency services methodology in Alberta. *Health Manage Forum* 1995; 8(1):31-7.
65. Elinson R, Friedman SM. Emergency physician time and motion study. *CJEM* 2004; 6(2).
66. Elinson RS, Friedman M. Emergency physician time and motion study. *Acad Emerg Med* 2004; 11(5):457-8.
67. Eriksen CB, Jensen BN, Vyberg B, Ahrenholt E, Lindballe A, Kjaergaard B. Use and misuse

- of an outpatient casualty department. *Ugeskr Laeger* 1991; 153(10):712-5.
68. Fajardo-Ortiz G, Ramirez-Fernandez FA. Review of admissions to the emergency unit of the specialist hospital of the Institute of Social Security responsible for the treatment of civil servants in the Puebla State, 1996. *World Hosp Health Serv* 2000; 36(1):14-7.
  69. Farrell RG. Use of an observation ward in a community hospital. *Ann Emerg Med* 1982; 11(7):353-7.
  70. Fatovich DM, Jacobs IG. NTS versus waiting time: an indicator without definition. *Emerg Med* 2001; 13(1):47-50.
  71. Fernandes CM, Christenson JM, Price A. Continuous quality improvement reduces length of stay for fast-track patients in an emergency department. *Acad Emerg Med* 1996; 3(3):258-63.
  72. Fernandes CM, Daya MR, Barry S, Palmer N. Emergency department patients who leave without seeing a physician: the Toronto Hospital experience. *Ann Emerg Med* 1994; 24(6):1092-6.
  73. Finefrock SC. "Fast tracking" ED patients with chest pain: integrating the chest pain evaluation unit and the observation unit. *J Emerg Nurs* 1995; 21(5):417-22.
  74. Fisher BA, Wittlake WA. Enhancing the medical practice: consorting with the emergency department. *J Med Pract Manage* 2000; 15(4):181-6.
  75. Fruhwirth K. Staff involvement in the ED promotes effective change. *Nurs Manage* 1995; 26(9):102.
  76. George JE, Quattrone MS. Patients who leave without being seen. *J Emerg Nurs* 1992; 18(3):267-8.
  77. Gerbeaux P, Ledoray V, Liauthaud H, Torro D, Takun K, Thirree R *et al*. Medical student effect on emergency department length of stay. *Ann Emerg Med* 2001; 37(3):275-8.
  78. Goldman RD, MacPherson A, Schuh S, Mulligan C, Pirie JR. Patients who leave the pediatric emergency department without being seen: why don't they stay and where do they go? *CJEM* 2003; 5(3).
  79. Graber DJ, Ardagh MW, O'Donovan P, St George I. A telephone advice line does not decrease the number of presentations to Christchurch emergency department, but does decrease the number of phone callers seeking advice. *Mt Sinai J Med* 2003; 116(1177):U495.
  80. Graff LG, Wolf S, Dinwoodie R, Buono D, Mucci D. Emergency physician workload: a time study. *Ann Emerg Med* 1993; 22(7):1156-63.
  81. Grafstein EJ, Innes GD, Westman J, Christenson JM, Thorne A. The inter-rater reliability of triage in an acute care emergency department setting. *Acad Emerg Med* 2003; 10(5):527.
  82. Groll D. Can the Ontario universal influenza immunization program reduce emergency department overcrowding? *CJEM* 2002; 4(4).

83. Groll D, Henry B. Can a universal influenza immunization program reduce emergency department volume? *CJEM* 2002; 4(4):245.
84. Hadden DS, Dearden CH, Rocke LG. Short stay observation patients: general wards are inappropriate. *J Accid Emerg Med* 1996; 13(3):163-5.
85. Hadjistavropoulos H, Clark J, Hardenne D, Lochbaum B, Larrivee D. Use of an ER audit to build recommendations for improving quality of care. Part II: follow-up to an ER study. *Healthc Manage Forum* 2000; 13(2):54-7.
86. Havill JH, Van Alphen S, Fairweather S, Van der Pyl M. Waiting in the emergency department. *N Z Med J* 1996; 109(1021):159-61.
87. Hellwig SD, Piper L, Naylor E. Forty hours under pressure: a rapid-response improvement team achieves synergy. *J Healthc Qual* 2002; 24(3):21-3.
88. Hirshon JM, Kirsch TD, Mysko WK, Kelen GD. Effect of rotational patient assignment on emergency department length of stay. *J Emerg Med* 1996; 14(6):763-8.
89. Hoag-Apel CM. Hurry up and wait. *Nurs Manage* 1996; 27(3):61-2.
90. Hobbs D, Kunzman SC, Tandberg D, Sklar D. Hospital factors associated with emergency center patients leaving without being seen. *Am J Emerg Med* 2000; 18(7):767-72.
91. Hobbs D, Sklar D, Tandberg D, Kinzman SC. Factors predicting patients who leave without being seen. *Acad Emerg Med* 1999; 6(5):399.
92. Hoffenberg S, Hill MB, Houry D. Does sharing process differences reduce patient length of stay in the emergency department? *Ann Emerg Med* 2001; 38(5):533-40.
93. Hoxhaj S, Moseley MG, Reese CL. Nurse staffing levels affect the number of emergency department patients who leave without treatment. *Acad Emerg Med* 2004; 11(5):459-60.
94. Huang XM. A planning model for requirement of emergency beds. *IMA J Math Appl Med Biol* 1995; 12(3-4):345-53.
95. Huddy J, McKay J, Culp K. Computer simulation: making better operational and architectural ED design decisions. *J Emerg Nurs* 1999; 25(4):307-10.
96. Janiak BD. Physician triage: an experiment. *Top Emerg Med* 1997; 19(2):47-50.
97. Jelinek GA, Mountain D, O'Brien D, Rogers IR, Wilkes G, Wenban J *et al.* Re-engineering an Australian emergency department: can we measure success? *J Qual Clin Pract* 1999; 19(3):133-8.
98. Jones A, Ridener AJ, Smith KG. Preparing for change: emergency department queuing theory and computer simulation. *Top Emerg Med* 1997; 19(2):40-6.
99. Jones G. Ways of reducing the waiting times for patients in A&E. *Nurs Stand* 1996; 92(11):31-2.

100. Kaplan LJ, Santora TA, Blank-Reid CA, Trooskin SZ. Improved emergency department efficiency with a three-tier trauma triage system. *Injury* 1997; 28(7):449-53.
101. Kennedy J, Rhodes K, Walls CA, Asplin BR. Access to emergency care: restricted by long waiting times and cost and coverage concerns. *Ann Emerg Med* 2004; 43(5):567-73.
102. Khanna R, Chaudhry MA, Prescott M. Emergency department patients who leave the department without being seen by a doctor. *Eur J Emerg Med* 1999; 6(3):233-5.
103. Lee AH, Meuleners LB, Zhao Y, Intrapanya M, Palmer D, Mowatt E. Emergency presentations to Northern territory public hospitals: demand and access analysis. *Aust Health Rev* 2003; 26(2):43-8.
104. Lee KM, Wong TW, Chan R, Lau CC. A study of patients who leave without notice in an A&E department. *Accid Emerg Nurs* 1998; 6(2):118-21.
105. Legrand A, Thys F, Vermeiren E, Touwaide M, D'Hoore W, Hubin V, *et al.* Validation of a triage scale: first step in patient admission and in emergency service models. *Rech Soins Infirm* 2003; (72):145-9.
106. Liao HC, Liaw SJ, Hu PM, Lee KT, Chen CM, Wang FL. Emergency department patients who leave without being seen by a doctor: the experience of a medical center in northern Taiwan. *Chang Gung Med J* 2002; 25(6):367-73.
107. Lipke GK, Cauci A, Nelson BK. Waiting time correlates with patient walk-out rates but not with patient satisfaction scores. *Acad Emerg Med* 2003;10(5):522.
108. Liubin FA. On the volume of emergency hospital service to the urban population. *Zdravookhr Ross Fed* 1967; 11(7):8-11.
109. Lowe RA, McConnell KJ, Lapidus J, Weathers C, Adams A, Bauman B *et al.* Impact of Oregon health plan cutbacks on emergency department use. *Acad Emerg Med* 2004; 11(5):460-1.
110. Malone RE. Whither the almshouse? Overutilization and the role of the emergency department. *J Health Polit Policy Law* 1998; 23(5):795-832.
111. Marinovitch A, Afilalo J, Afilalo M, Colacone A, Unger B, Giguere C *et al.* Impact of ambulance transportation on the use of resources in the emergency department. *CJEM* 2003; 5(3).
112. Mayor S. Hospitals take short term measures to meet targets. *BMJ* 2003; 326(7398):1054.
113. McD Taylor D, Bennett DM, Cameron PA. A paradigm shift in the nature of care provision in emergency departments. *Emerg Med J* 2004; 21(6):681-4.
114. McGuire F. Using simulation to reduce length of stay in emergency departments. *J Soc Health Syst* 1997; 5(3):81-90.
115. Melnick GA, Nawathe AC, Bamezai A, Green L. Emergency department capacity and access

- in California, 1990-2001: an economic analysis. *Health Aff* 2004; W136.
116. Metz M, Marcotte A, Vilke GM. The effect of decreasing ambulance diversion hours on ED interfacility transfers. *J Emerg Nurs* 2004; 30(5): 411.
  117. Miller MJ, Ferrin DM, Szymanski JM. Simulating Six Sigma improvement ideas for a hospital emergency department. Chick S, Sánchez PJ, Ferrin D, Morrice DJ, editors. *Proceedings of the 2003 Winter Simulation Conference*; 2003 Dec 7-10; New Orleans.
  118. Montague J. The state of emergency: challenges for contract emergency physicians. *Hosp Health Netw* 1994; 68(19).
  119. Nawathe AC, Stone SC, Melnick GA, Bamezai A. Emergency department intervention of key clinical procedures reduces inpatient hospital length of stay: policy implications. *Acad Emerg Med* 2004; 11(5):463-4.
  120. Nguyen TT, Leber M, Irizarry L, Drummer J, Ahmed S, Khatoon S. The effect of nurse staffing on disposition times and walkout rates. *Acad Emerg Med* 2002; 9(5):540.
  121. Nollman J, Colbert K. Successful fast tracks: data and advice. *J Emerg Nurs* 1994; 20(6):483-6.
  122. Norton RL, Kim E, Gunnels MD, Zechnich AD, Mann NC. Emergency department observation unit reduces length of stay for mild brain injured patients. *Acad Emerg Med* 2000; 7(5): 589.
  123. Nunez-Rocha GM, Flores-Guerrero FJ, Salinas-Martinez AM, Villarreal-Rios E, Garza-Elizondo M E. Waiting time? Triage: an alternative in emergency department. *Rev Invest Clin* 2004; 56(3):314-20.
  124. O'Connor RE, Reese CL. Correlation between emergency department patients' recall of length of stay and their actual time in the department. *Acad Emerg Med* 2001; 8(5):577.
  125. Ovens HJ, Chan BTB. Frequent fliers in the emergency department. *CJEM* 2001; 3(2).
  126. Quinn JV, Polevoi SK, Kramer NR, Callaham ML. Factors associated with patients who leave without being seen. *Acad Emerg Med* 2003; 10(5):523-524.
  127. Ray CE, Jagim M, Agnew J, McKay JIJ, Sheehy S. ENA's new guidelines for determining emergency department nurse staffing. *J Emerg Nurs* 2003; 29(3):245-53.
  128. Reeder T, Locascio E, Tucker J, Czaplijski T, Benson N, Meggs W. ED utilization: the effect of changing demographics from 1992 to 2000. *Am J Emerg Med* 2002; 20(7):583-7.
  129. Reeder TJ, Tucker JL, Cascio ES, Czaplijski TJ, Benson NH, Meggs WJ. Trends in emergency department utilization: effect of changing demographics. *Acad Emerg Med* 2001; 8(5):577.
  130. Richardson DB. Association of daily patient care time with adverse events in patients who do not wait to be seen. *Acad Emerg Med* 2004; 11(5):461-2.

131. Richardson JR, Braitberg G, Yeoh MJ. Multidisciplinary assessment at triage: a new way forward. *Emerg Med Australas* 2004; 16(1):41-6.
132. Ross MA, Compton S, Richardson D, Jones R, Nittis T, Wilson A. The use and effectiveness of an emergency department observation unit for elderly patients. *Ann Emerg Med* 2003; 41(5):668-77.
133. Ross MA, Naylor S, Compton S, Gibb KA, Wilson AG. Maximizing use of the emergency department observation unit: a novel hybrid design. *Ann Emerg Med* 2001; 37(3):267-74.
134. Rotstein Z, Wilf-Miron R, Lavi B, Shahar A, Gabbay U, Noy S. The dynamics of patient visits to a public hospital ED: a statistical model. *Am J Emerg Med* 1997; 15(6):596-9.
135. Rowe BH, Peter C, Bullard M, Alibhai A, Saunders D. Reasons why patients leave without being seen from the emergency department. *Acad Emerg Med* 2003; 10(5):513.
136. Rucker DW, Setnik G, Brennan TA, Burstin HR. Willingness to wait for an appointment rather than going to the ED. *Acad Emerg Med* 1999; 6(5):538.
137. Ruger JP, Richter CJ, Lewis LM. Improving accuracy of triage of "borderline" patients. *Acad Emerg Med* 2003; 10(5):530.
138. Sanko DJ, Vellman WP. Security measures: what can be done? *Top Emerg Med* 1994; 16(3):61-9.
139. Sansa Perez L, Orus Escola T, Juncosa Font S, Barredo Hernandez M. Attendance frequency of the hospital emergency services: use of the primary health care services of a pediatric population. *An Esp Pediatr* 1996; 44(2):105-8.
140. Sansa Perez L, Orus Escola T, Juncosa Font S, Barredo Hernandez M, Traveria Casanova J. Attendance frequency of the hospital emergency services: motivations and characteristics of the paediatrics emergencies from a Health Center. *An Esp Pediatr* 1996; 44(2):97-104.
141. Sarver JH, Cydulka RK. Emergency department provision of nonurgent care and waiting time to see a physician. *Acad Emerg Med* 2001; 8(5):576.
142. Saunders CE. Time study of patient movement through the emergency department: sources of delay in relation to patient acuity. *Ann Emerg Med* 1987; 16(11):1244-8.
143. Saunders CE, Makens PK, Leblanc LJ. Modeling emergency department operations using advanced computer simulation systems. *Ann Emerg Med* 1989; 18(2):134-40.
144. Saunders D, Alibhai A. Understanding emergency department pressures in capital health. Edmonton: Alberta Centre for Health Services Utilization Research; 2001.
145. Saunders LD, Alibhai A, Ness K, Estey A, Bear RA. Variations in the use of emergency departments in Alberta's Capital Health region 1998-2000. *Healthc Manage Forum* 2004; 17(2):16-21.
146. Schneiderman N, Reed V. Materials for emergency department laboratory. *Emerg Med Clin*

North Am 1986; 4(2):397-404.

147. Schull M, Chan B, Schultz S. Increased emergency department volumes but decreased overall utilization: Ontario's hospital restructuring paradox. *CJEM* 2002; 4(2).
148. Schwab RA, DeSorbo SM, Cunningham MR, Craven K, Watson WA. Using statistical process control to demonstrate the effect of operational interventions on quality indicators in the emergency department. *J Healthc Qual* 1999; 21(4):38-41.
149. Shapiro T, Salo D, Vidal O, Mojares G, Malinkar A. A comparison of patient self-triage to fast-track with emergency medicine nurses and the emergency severity index. *Acad Emerg Med* 2004; 11(5):455.
150. Sharma V, Simon SD, Bakewell JM, Ellerbeck EF, Fox MH, Wallace DD. Factors influencing infant visits to emergency departments. *Pediatrics* 2000; 106(5):1031-9.
151. Shaw KN, Ruddy RM, Gorelick MH. Pediatric emergency department directors' benchmarking survey: fiscal year 2001. *Pediatr Emerg Care* 2003; 19(3):143-7.
152. Shipman C, Longhurst S, Hollenbach F, Dale J. Using out-of-hours services: general practice or A&E? *Fam Pract* 1997; 14(6):503-9.
153. Simpson AN, Wardrope J, Burke D. The Sheffield experiment: the effects of centralising accident and emergency services in a large urban setting. *Emerg Med J* 2001; 18(3):193-7.
154. Sinreich D, Marmor Y. A simple and intuitive simulation tool for analyzing emergency department operations. In: Ingalls RG, Rossetti MD, Smith JS, Peters BA, editors. *Proceedings of the 2004 Winter Simulation Conference*; 2004 Dec 5-8.
155. Smeltzer CH, Curtis L. Analyzing patient time in the emergency department. *QRB Qual Rev Bull* 1986; 12(11):380-2.
156. Smith RD, McNamara JJ. Why not your pediatrician's office? A study of weekday pediatric emergency department use for minor illness care in a community hospital. *Pediatr Emerg Care* 1988; 4(2):107-11.
157. Sookram S, Riddle K, Chang E, Sosnowski T. Description of ambulance diversions in Edmonton region. *Prehospital Disaster Med* 2002; 17(2):91-5.
158. Spence JM, Beaton DE, Murray MJ, Morrison LJ. Does the Canadian triage and acuity scale correlate with admission to the hospital from the emergency department? *Acad Emerg Med* 2004; 11(5):456-7.
159. Spence JM, Murray MJ, Morrison LJ. Does emergency department activity level affect triage categorization and admission to the hospital? *Acad Emerg Med* 2004; 11(5):457.
160. Spence JM, Murray MJ, Morrison LJ. Does emergency department activity level affect triage categorization and admission to the hospital? *CJEM* 2004; 6(3).
161. Spilseth EE, Wang N, Camargo Jr CA. National study of ED patients who "left before being

- seen" by a physician, 1992-2000. *Acad Emerg Med* 2003; 10(5):575.
162. Sprivulis P. Estimation of the general practice workload of a metropolitan teaching hospital emergency department. *Emerg Med (Fremantle)* 2003; 15(1):32-7.
  163. Stair TO, Howell JM. How long will it take? How much will it cost?: multiple regression and neural network programs at ED triage. *Am J Emerg Med* 1995; 13(1):118-9.
  164. Stead LG, Boenau I, Skiendzielewski J, Counselman FL. A survey of academic departments of emergency medicine regarding operation and clinical practice: two years later. *Acad Emerg Med* 2003; 10(4):393-6.
  165. Stiell A, Forster A, Stiell IG, van Walraven C. The prevalence and effect of information gaps in the emergency department. *Acad Emerg Med* 2003; 10(5):512-3.
  166. Stiell A, Forster A, Stiell IG, van Walraven C. The prevalence and effect of information gaps in the emergency department. *CJEM* 2003; 5(3).
  167. Stobbe K, Dewar D, Thornton C, Duchaine S, Tremblay PM, Howe D. Canadian emergency department triage and acuity scale (CTAS): rural implementation statement. *Can J Rural Med* 2002; 7(4):271.
  168. Stock LM, Bradley GE, Lewis RJ, Baker DW, Sipsey J, Stevens CD. Patients who leave emergency departments without being seen by a physician: magnitude of the problem in Los Angeles County. *Ann Emerg Med* 1994; 23(2):294-8.
  169. Stolte E, Iwanow R, Hall C. Capacity-related interfacility patient transports: patients affected, waiting times, and associated morbidity. *Acad Emerg Med* 2004; 11(5):461.
  170. Stuart P. A casemix model for estimating the impact of hospital access block on the emergency department. *Emerg Med Australas* 2004; 16(3):201-7.
  171. Sullivan AF, Auerbach BS, Schafermeyer RW, Camargo Jr CA. Current status of US emergency departments. *Acad Emerg Med* 2004; 11(5):454.
  172. Szegedy-Maszak M. Emergency of the mind. *U.S. News World Rep* 2004; 136(16):62.
  173. Tanabe P, Gilboy N, Travers D, Rosenau A, Martinovich Z, Weiss KB *et al.* Optimizing triage of high-acuity patients: revision of the emergency severity index (ESI) level 1 & 2 criteria. *Acad Emerg Med* 2004; 11(5):455.
  174. Tanabe P, Gimbel R, Yarnold PR, Adams JG. The Emergency Severity Index (version 3) 5-level triage system scores predict ED resource consumption. *J Emerg Nurs* 2004; 30(1):22-9.
  175. Tintinalli J, Hayden S, Larson J. Emergency department phlebotomist: a failed experiment. *Ann Emerg Med* 2004; 44(2):185-6.
  176. Tran TP, Schutte WP, Muelleman RL, Wadman MC. Provision of clinically based information improves patients' perceived length of stay and satisfaction with emergency physicians. *Acad Emerg Med* 2002; 9(5):541.

177. Udezue E. A five-year experience of a short stay observation unit in Saudi Arabia. *Ann Saudi Med* 2003; 23(1-2):72-5.
178. Emergency departments: unevenly affected by growth and change in patient use. United States General Accounting Office Human Resources Division. Report to the Chairman, Subcommittee on Health for Families and the Uninsured, Committee on Finance, U.S. Senate. Washington: United States General Accounting Office; 1993.
179. Vazquez Quiroga B, Pardo Moreno G, Fernandez Cantalejo G, Canals Aracil M, Delgado Nicolas MA, Navas Alonso M. Why do our patients go to hospital emergency departments? [in Spanish]. *Aten Primaria* 2000; 25(3):172-5.
180. Walls CA, Rhodes KV, Kennedy JJ. The emergency department as usual source of medical care. Estimates from the 1998 National Health Interview Survey. *Acad Emerg Med* 2002; 9(5):540.
181. Walsh BW, Eskin B, Rothman J, Junker E. The effects of a physician slow-down on emergency department volume. *Acad Emerg Med* 2004; 11(5):454-5.
182. Walsh M. The health belief model and use of accident and emergency services by the general public. *J Adv Nurs* 1995; 22 (4):694-9.
183. Wartman SA, Taggart MP, Palm E. Emergency room leavers: a demographic and interview profile. *J Community Health* 1984; 9 (4):261-8.
184. Washington DL, Stevens CD, Shekelle PG, Baker DW, Fink A, Brook RH. Safely directing patients to appropriate levels of care: guideline-driven triage in the emergency service. *Ann Emerg Med* 2000; 36(1):15-22.
185. Weinick RM, Billings J, Thorpe JM. Ambulatory care sensitive emergency department visits: a national perspective. *Acad Emerg Med* 2003; 10(5):525-6.
186. Weinick RM, Owens PL, Andrews RM, Sommers JP, Machlin SR. How many emergency department visits are there? *Acad Emerg Med* 2004; 11(5):464-5.
187. Weiss R. Building patient volume through "runway" management. *Health Prog* 2004; 85(1):12-3.
188. Weissberg MP, Heitner M, Lowenstein SR, Keefer G. Patients who leave without being seen. *Ann Emerg Med* 1986; 15(7):813-7.
189. White-Means SI, Thornton MC. What cost savings could be realized by shifting patterns of use from hospital emergency rooms to primary care sites? *Am Econ Rev* 1995; 85(2):138-42.
190. Wong FK, Chow S, Chang K, Lee A, Liu J. Effects of nurse follow-up on emergency room revisits: a randomized controlled trial. *Soc Sci Med* 2004; 59(11):2207-18.
191. Wuerz R, Milne L, Eitel D, Wiencek J, Simonds W. Outcomes are predicted by a new five-level triage algorithm. *Acad Emerg Med* 1999; 6(5):398.

192. Wuerz RC, Milne LW, Eitel DR, Travers D, Gilboy N. Reliability and validity of a new five-level triage instrument. *Acad Emerg Med* 2000; 7(3):236-42.
193. Wuerz RC, Travers D, Yazhari RH. Implementation of five-level triage at two university hospitals. *Acad Emerg Med* 2000; 7(5):522.
194. Zimmermann PG. The case for a universal, valid, reliable 5-tier triage acuity scale for US emergency departments. *J Emerg Nurs* 2001; 27(3):246-54.

**Abstract of published article (20)**

1. Afilalo M, Boivin JF, Beique M, Colacone A, Dankoff J, Giguere C *et al.* Development and evaluation of a measurement of emergency room overcrowding. Ottawa: Canadian Health Services Research Foundation; 2001.
2. Derlet RW, Richards JR, Kravitz RL. ED overcrowding: definition and magnitude. *Acad Emerg Med* 2000; 7(5):544.
3. Derlet RW, Weiss SJ, Ernst AA, Nick TG, Arndahl J, Richards JR *et al.* Development of an emergency department overcrowding scale. Results of the national ED overcrowding study (NEDOCS). *Acad Emerg Med* 2002; 9(5):366.
4. Innes GD, Grafstein EJ, Christenson JM, Purssel R, Stenstrom R. Does physician order entry reduce emergency department length of stay (LOS) in an overcrowded emergency department? *Acad Emerg Med* 2003; 10(5):532.
5. McMullan JT, Veser FH. Emergency department volume and patient acuity as factors in patients leaving without treatment. *Acad Emerg Med* 2003; 10(5):528.
6. Nelson BK, Partovi SN, Walsh MJ, Bryan ED. Faculty triage shortens emergency department length of stay. *Acad Emerg Med* 2000; 7(5):556.
7. Reeder TJ, Burleson DL, Garrison HG. The overcrowded emergency department: perception vs. reality. *Acad Emerg Med* 2003; 10(5):529.
8. Rehmani R. Emergency section and overcrowding in a teaching university hospital of Karachi, Pakistan. *CJEM* 2003; 5(3).
9. Schull M, Mamdani M, Redelmeier D. Influenza in the elderly and emergency department overcrowding. *CJEM* 2002; 4(2).
10. Schull MJ, Mamdani M. How influenza outbreaks affect emergency department overcrowding and ambulance diversion. *Acad Emerg Med* 2001; 8(5):574.
11. Schull MJ, Morrison LJ, Vermeulen M, Redelmeier DA. Emergency department gridlock and pre-hospital delays for cardiac patients. *Acad Emerg Med* 2003; 10(5):451.
12. Schull MJ, Morrison LJ, Vermeulen M, Redelmeier DA. Emergency department gridlock and pre-hospital delays for cardiac patients. *CJEM* 2003; 5(3).

13. Schull MJ, Redelmeier DA, Szalai JP, Schwartz B. Trends in ambulance diversion for Toronto emergency departments from 1991 to 1999. *Acad Emerg Med* 2000; 7(5):520.
14. Schull MJ, Szalai JP, Schwartz B, Redelmeier DA. Ambulance diversion and emergency department overcrowding before and following the systematic restructuring of hospitals. *Acad Emerg Med* 2001; 8(5):574-5.
15. Schull MJ, Szalai JP, Schwartz B, Redelmeier DA. Emergency department overcrowding in Toronto from 1991 to 2000: the effect of systematic hospital restructuring. *CJEM* 2001; 3(2).
16. Schull MJ, Vermeulen MJ, Slaughter G, Morrison LJ, Daly P. Overcrowding of Ontario emergency departments and door-to-needle time delays in acute myocardial infarction. *CJEM* 2004; 6(3).
17. Vermeulen MJ, Schull MJ. Emergency department overcrowding as an ecologic problem: a comparison of measurement methods and the effect on time to thrombolysis. *Acad Emerg Med* 2004; 11(5):453.
18. Vermeulen MJ, Schull MJ. Emergency department overcrowding as ecologic problem: a comparison of measurement methods and the effect on time to thrombolysis. *CJEM* 2004; 6(3).
19. Vilke GM, Lev R, Castillo EM, Murrin PA, Chan TC. Prospective countywide trial to decrease ambulance diversion hours. *Acad Emerg Med* 2003; 10(5):465.
20. Weiss SJ, Arndahl J, Ernst AA, Derlet RW, Nick TG. Development of a site sampling form for evaluation of ED overcrowding. *Acad Emerg Med* 2001; 8(5):577-8.

**No measures provided (20)**

1. Abenhaim HA, Kahn SR, Raffoul J, Becker MR. Program description: a hospitalist-run, medical short-stay unit in a teaching hospital. *CMAJ* 2000; 163(11):1477-80.
2. Anonymous. Use real-time data to track delays to floors. *ED Manag* 1998; 10(2):22-4.
3. Buchanan L, Powers RD. Establishing an NP-staffed minor emergency area. *Nurse Pract* 1997; 22(4):175-8.
4. Crane K, Sparks L. An admission avoidance team: its role in the Accident & Emergency department. *Accid Emerg Nurs* 1999; 7(2):91-5.
5. Estey A, Ness K, Saunders LD, Alibhai A, Bear RA. Understanding the causes of overcrowding in emergency departments in the Capital Health Region in Alberta: a focus group study. *CJEM* 2003; 5(2):87-94.
6. Fisher BA, Wittlake WA. Three year results of a comprehensive emergency department model. *Top Emerg Med* 1999; 21(3):73-9.
7. Gantt LT. A strategy to manage overcrowding: development of an ED holding area. *J Emerg Nurs* 2004; 30(3):237-42.

8. Gonzalez CJ, Gonzalez M, Rios NM. Improving the quality of service in an emergency room using simulation-animation and total quality management. *Comput Ind Eng* 1997; 33(1-2):97.
9. Goodacre S, Morris F, Tesfayohannes B, Sutton G. Should ambulant patients be directed to reception or triage first? *Emerg Med J* 2001; 18(6):441-3.
10. Grumbach K, Keane D, Bindman A. Primary care and public emergency department overcrowding. *Am J Public Health* 1993; 83(3):372-8.
11. Hansagi H, Carlsson B, Olsson M, Edhag O. Trial of a method of reducing inappropriate demands on a hospital emergency department. *Public Health* 1987; 101(2):99-105.
12. Hill KN. Responses to access block in Australia: the Alfred Hospital. *Med J Aust* 2003; 178(3):110-1.
13. Hobgood CD, Villani J, Quattlebaum R. Impact of emergency department volume on RN time at the bedside. *Acad Emerg Med* 2004; 11(5):463.
14. Krochmal P, Riley TA. Increased health care costs associated with ED overcrowding. *Am J Emerg Med* 1994; 12(3):265-6.
15. Puerzer RJ. The development of a patient tracking and control system for use in the emergency department [dissertation]. Pittsburgh: University of Pittsburgh; 1997.
16. Richardson DB. Responses to access block in Australia: Australian Capital Territory. *Med J Aust* 2003; 178(3):103-4.
17. Scott G. NHS direct protocols in A&E slash waiting times. *Nurs Stand* 2000; 14(26):7.
18. Sempere-Selva T, Peiro S, Sendra-Pina P, Martinez-Espin C, Lopez-Aguilera I. Inappropriate use of an accident and emergency department: magnitude, associated factors, and reasons--an approach with explicit criteria. *Ann Emerg Med* 2001; 37(6):568-79.
19. Shah CP, Carr LM. Triage: a working solution to over crowding in the emergency department. *CMAJ* 1974; 110(9):1039.
20. Shea SS, Senteno J. Emergency department patient throughput: a continuous quality improvement approach to length of stay. *J Emerg Nurs* 1994; 20(5):355-60.

**Did not meet study design criteria (3)**

1. Cobelas C, Cooper C, Ell M, Hawthorne G, Kennedy M, Leach D. Quality management and the emergency services enhancement program. *J Qual Clin Pract* 2001; 21(3):80-5.
2. Geer R, Smith J. Strategies to take hospitals off (revenue) diversion. *Healthc Financ Manage* 2004; 58(3):70-4.
3. Richardson DB, Kelly AM, Baggoley CJ, Fulde GWO, Rogers IJ, Ieraci S. Variation in triage categorization: does daily activity make a difference? *Acad Emerg Med* 1999; 6(5):397.

## APPENDIX 6: Articles Awaiting Assessment

### Pending translation

1. Carmel A, Amital H, Shemer Y, Sahar A. Why do the leave? Clinical characteristics of patients who leave the emergency room against medical advice. *Harefuah* 1998; 134(6):445-9.
2. Bilo HJG, Meyboom-De Jong B, Van der Kam WJ, Pierik EGJM, Bosveld HPE. No Friday afternoon peak in the patient flow to the emergency department of De Weezenlanden Hospital in Zwolle, May/June 1997 [in Dutch]. *Ned Tijdschr Geneesk* 2000; 144 (8):396-7.

### Pending retrieval

1. California emergency services: a system in crisis. Sacramento (CA): California Medical Association; 2001.
2. Ambulance service. Code red: hospital emergency departments. North Sydney: Department of Health NSW; 1998.
3. Department of Health Sciences Clinical Evaluation, University of York, York Health Economics Consortium Plymouth, University Office of the Vice Chancellor. The rise in emergency admissions project: executive summary. Plymouth, United Kingdom: Coventry Business School, Coventry University and University of York; 1998.
4. Hospital Report Research Collaborative and the Government of Ontario. Emergency department care: hospital specific results. 2004.
5. Ly N. Trends in patient waiting time in emergency departments in the US, 1997-2000. *AHSRHP Annual Meeting* 2002; 19:28.
6. Massachusetts Health Care Task Force. Hospital capacity, crowding and ambulance diversion. Chelsea (MA): Health Care Finance and Policy, Commonwealth of Massachusetts; 2001.
7. Rylko-Bauer B. The role of freestanding emergency centers in the delivery of health care: perspectives on change in American medicine (room, non-urgent, primary practitioners, ambulatory). Lexington (KY): University of Kentucky; 1985.
8. Sanchez M, Miro O, Coll-Vinent B, Bragulat E, Espinosa G, Gomez-Angelats E *et al.* Emergency department overcrowding: quantification of associated factors. *Med Clin (Barc)* 2003; 121(5):161-72.
9. Schur C, Mohr P, Zhao L. Emergency department use in Maryland: a profile of users, visits and ambulance diversion. Bethesda (MD): The Project HOPE Center for Health Affairs; 2003.

## APPENDIX 7: Characteristics of Included Studies in Systematic Review of Measures to Document Overcrowding in ED

| Study  | Design                                  | Objectives   | Measures  | Description   | Type of Measure            | Measure Category | Purpose                       |
|--|---|--|---|---|----------------------------|------------------|-------------------------------|
| Afilalo, <sup>35</sup><br>Canada             | cross-sectional study, multicentre      | to develop and evaluate a measure of ED overcrowding, ED overcrowding not defined                                    | LOS   | time from arrival in emergency triage to disposition                  | ED LOS                     | throughput       | discriminative or descriptive |
| Afilalo, <sup>36</sup><br>Canada             | prospective cohort study, multicentre   | to develop a tool that quantifies predicted LOS of ED patients, ED overcrowding not defined                          | LOS   | not described   | ED LOS                     | throughput       | discriminative or descriptive |
| Agouridakis, <sup>37</sup><br>Greece         | prospective cohort study, Single centre | to evaluate workload and case mix of ED, with aim of determining causes of overcrowding, ED overcrowding not defined | total number of ED patient visits per year                                  | not described   | ED patient volumes overall | input            | discriminative or descriptive |
|  |   |  | daily number of patients visiting ED in relation to number of hospital beds | not described   | ED patient volumes overall | throughput       | discriminative or descriptive |
| Aharonson-Daniel, <sup>38</sup><br>Hong Kong | cross-sectional study, single centre    | to identify and define factors influencing flow of patients through ED, ED overcrowding not defined                  | arrival rate  | number of arrivals at given times                                     | ED patient volumes overall | input            | discriminative or descriptive |
|  |   |  | inter-arrival times   | difference between two consecutive arrivals                           | ED times                   | input            | discriminative or descriptive |
|  |   |  | number of patients in queue at given time                                   | number of patients registered but not yet treated                     | ED patient waiting volumes | throughput       | discriminative or descriptive |
|  |   |  | number of patients in system  | number of patients in system but not yet discharged                   | ED patient volumes         | throughput       | discriminative or descriptive |
|  |   |  | waiting times for first contact with doctor                                 | difference between arrival time and time of first entrance to cubicle | ED times                   | throughput       | discriminative or descriptive |
|  |   |  | treatment time  | patients' duration of stay in cubicles                                | ED times                   | throughput       | discriminative or descriptive |
|  |   |  | total service time  | total time spent in system (from arrival to discharge)                | ED times                   | throughput       | discriminative or descriptive |

| Study   | Design                                    | Objectives   | Measures   | Description  | Type of Measure            | Measure Category | Purpose                       |
|---|---|--|--|--|----------------------------|------------------|-------------------------------|
| Allen, <sup>39</sup><br>Canada                                | before-and-after study, single centre     | to determine time spent by patients in ED of hospital; to assess whether full-time physician supervision of interns appreciably influenced time spent in ED<br>ED overcrowding not defined   | time spent in ED   | total interval between arrival in ED and departure   | ED times                   | throughput       | evaluative                    |
|   |   |  | time awaiting family physician                           | interval from arrival of patient to arrival of family physician in ED                        | ED times                   | throughput       | evaluative                    |
|   |   |  | time awaiting intern                                     | period that patient spent in ED until intern arrived to attend him or her                    | ED times                   | throughput       | evaluative                    |
|   |   |  | time awaiting nurse                                      | mean interval between patient arrival in ED and attendance by nurse                          | ED times                   | throughput       | evaluative                    |
| American College of Emergency Physicians, <sup>40</sup><br>US | cross-sectional study, multicentre        | to gauge impact of ED overcrowding on patient care; to assess emergency physicians' estimations about significance of ED overcrowding problem, contributing factors, and obstacles to solving problem; ED overcrowding defined as not having "surge capacity" to respond to sudden increases in patient volume | annual ED patient volume                                 | number of patients attended (care provided) per year in ED                                   | ED patient volumes overall | input            | discriminative or descriptive |
|   |   |  | time of boarding patients                                | time (in hours) to wait for in-patient bed   | access block               | output           | discriminative or descriptive |
|   |   |  | boarding of patients                                     | percentage of admitted patients boarded in ED until in-patient staffed beds become available | access block               | output           | discriminative or descriptive |
| Anantharaman, <sup>41</sup><br>Singapore                      | retrospective cohort study, single centre | to evaluate effectiveness of comprehensive electronic ambulance case record system, ED overcrowding not defined  | waiting time for critical care patients to be seen at ED | time from arrival in ED to time to be attended by ED physician                               | ED times                   | throughput       | evaluative                    |
| Anderson, <sup>42</sup><br>Canada                             | before-and-after study, multicentre       | to evaluate implementation of new system for ambulance diversions, ED overcrowding not defined   | percent of available time on diversion                   | not described  | ambulance diversion        | input            | evaluative                    |
| Andersson, <sup>43</sup><br>Sweden                            | prospective cohort study, multicentre     | to investigate if reduction of supply (number of existing ED and acute hospital beds) affected waiting times for patients; to explore causes of delays or overcrowding<br>ED overcrowding defined as high referral rates to EDs  | frequency of ED visits                                   | frequency of ED visits per minute  | ED patient volumes overall | input            | discriminative or descriptive |
|   |   |  | total LOS  | time from arrival at ED to exit (admission or discharge)                                     | ED LOS                     | throughput       | discriminative or descriptive |
|   |   |  | waiting time for examination by physician                | time from arrival to first examination by physician  | ED times                   | throughput       | discriminative or descriptive |

| Study                                | Design                                | Objectives   | Measures  | Description   | Type of Measure            | Measure Category | Purpose                       |
|--------------------------------------|---------------------------------------|--|---|---|----------------------------|------------------|-------------------------------|
|                                      |                                       |  | turnaround time between emergency and radiology departments | waiting time for report from radiology department   | ED times                   | throughput       | discriminative or descriptive |
| Andrulis, <sup>44</sup><br>US        | cross-sectional study, multicentre    | to assess extent and distribution of hospital and ED department crowding, ED crowding present when ED patients are ready but unable to be admitted to floor or intensive care unit (ICU) bed, and are held in ED   | annual ED visits  | mean number of annual ED visits   | ED patient volumes overall | input            | discriminative or descriptive |
|                                      |                                       |  | ED visits arriving by ambulance                             | percentage of ED visits arriving by ambulance for study period  | ED patient volumes overall | input            | discriminative or descriptive |
|                                      |                                       |  | days on holding   | number of days during study period that ED was required to hold admitted patients in ED for $\geq 4$ hours because of lack of vacant or staffed in-patient beds | access block               | output           | discriminative or descriptive |
|                                      |                                       |  | mean ED holding times for floor and ICU beds                | delay from time emergency patient is evaluated and orders are written for admission to ward or floor bed until patient leaves ED                                | ED times                   | output           | discriminative or descriptive |
|                                      |                                       |  | maximum holding time  | maximum time during study period that $\geq 1$ admitted patients held in ED before vacant floor bed became available  | ED times                   | output           | discriminative or descriptive |
| Ardagh, <sup>45</sup><br>New Zealand | controlled trial, single centre       | to test hypothesis that triaging certain ED patients through rapid assessment clinic (RAC) improves waiting times and times in department for all patients presenting to ED; to determine if RAC improved patient flow for department overall; ED overcrowding not defined | length of time in ED department                             | time spent in ED  | ED LOS                     | throughput       | evaluative                    |
|                                      |                                       |  | waiting time to be seen by doctor                           | waiting time for patients at each triage category to be seen by member of ED medical staff  | ED times                   | throughput       | evaluative                    |
| Asplin, <sup>46</sup><br>US          | prospective cohort study, multicentre | to develop reproducible measures of ED overcrowding that correlate with important patient and system outcomes, ED overcrowding not defined   | ambulance diversion episodes                                | not described   | ambulance diversion        | input            | discriminative or descriptive |
|                                      |                                       |  | acuity-adjusted measure of ED census                        | not described   | ED patient volumes overall | input            | discriminative or descriptive |

| Study                      | Design                                    | Objectives  | Measures  | Description  | Type of Measure            | Measure Category | Purpose                       |
|----------------------------|---|---|---|--|----------------------------|------------------|-------------------------------|
|                            |   |   | ED volumes  | not described  | ED patient volumes overall | input            | discriminative or descriptive |
|                            |   |   | ED workload   | not described  | ED administration          | throughput       | discriminative or descriptive |
|                            |   |   | percent of total ED bed-hours used to board in-patients | not described  | access block               | output           | discriminative or descriptive |
|                            |   |   | ED boarding burden of in-patients                       | not described  | access block               | output           | discriminative or descriptive |
|                            |   |   | total number of bed-hours available for patients in ED  | not described  | ED administration          | throughput       | discriminative or descriptive |
|                            |   |   | waiting times to see physician                          | not described  | ED times                   | throughput       | discriminative or descriptive |
|                            |   |   | ED occupancy  | not described  | ED administration          | throughput       | discriminative or descriptive |
|                            |   |   | patients LWBS   | not described  | LWBS                       | throughput       | discriminative or descriptive |
|                            |   |   | provider ratings of ED crowding                         | not described  | ED administration          | system           | discriminative or descriptive |
| Asplin <sup>47</sup><br>US | prospective cohort study, multicentre     | to derive ED overcrowding scale consistent with ED provider perspectives; to validate scale's performance using 4 adverse outcomes; ED overcrowding not defined   | number of boarders                                      | not described  | access block               | output           | predictive                    |
|                            |   |   | total number of ED patients                             | not described  | ED patient volumes overall | throughput       | predictive                    |
|                            |   |   | number of critical care ED patients                     | not described  | ED patient volumes         | throughput       | predictive                    |
|                            |   |   | ED LOS  | not described  | ED LOS                     | throughput       | predictive                    |
|                            |   |   | mean boarding times                                     | not described  | access block               | output           | predictive                    |
|                            |   |   | diversion episodes                                      | not described  | ambulance diversion        | input            | predictive                    |
| Baer, <sup>48</sup><br>US  | retrospective cohort study, single centre | to assess impact on ED of recently discharged in-patients and how they contribute to and worsen current situation of ED overcrowding, ED overcrowding not defined | total number of ED admissions                           | not described  | ED patient volumes overall | input            | discriminative or descriptive |
|                            |   |   | ED LOS  | time of ED registration to time of departure from ED | ED times                   | throughput       | discriminative or descriptive |

| Study                                | Design                                   | Objectives   | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|--------------------------------------|--|--|--|---|----------------------------|------------------|-------------------------------|
| Baker, <sup>49</sup><br>US           | prospective cohort study, single centre  | to determine whether population of patients who LWBS increases as ED waiting time increases, ED overcrowding not defined   | waiting time before receiving medical care or LWBS | time spent waiting for triage before receiving care or LWBS         | ED times                   | throughput       | discriminative or descriptive |
|                                      |  |  | patient waiting time                               | time from triage to time that patient first called to see physician | ED times                   | throughput       | discriminative or descriptive |
|                                      |  |  | patients who LWBS                                  | patients who did not answer 3 calls to see physician                | LWBS                       | throughput       | discriminative or descriptive |
| Barber Perez, <sup>50</sup><br>Spain | computer simulation model, single centre | to develop computer simulation model of ED as queue system; to design and analyze alternative functional structures of ED and their implications on resources, organization, and reallocation; ED overcrowding not defined | number of patients attended                        | not described   | ED patient volumes         | throughput       | discriminative or descriptive |
|                                      |  |  | ED occupancy rate                                  | not described   | ED patient volumes         | throughput       | discriminative or descriptive |
|                                      |  |  | number of patients leaving and entering system     | not described   | ED patient volumes         | throughput       | discriminative or descriptive |
|                                      |  |  | waiting times                                      | mean, maximum, and minimum waiting times                            | ED times                   | throughput       | discriminative or descriptive |
|                                      |  |  | time to triage                                     | mean, maximum, and minimum time to triage                           | ED times                   | throughput       | discriminative or descriptive |
|                                      |  |  | waiting times for being seen by doctor             | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                      |  |  | waiting time for tests                             | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                      |  |  | time spent in system                               | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                      |  |  | time to first examination                          | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                      |  |  | LOS in ED  | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                      |  |  | LOS in tests                                       | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                      |  |  | LOS in system                                      | not described   | ED times                   | throughput       | discriminative or descriptive |
| Baumann, <sup>51</sup><br>US         | prospective cohort study, single centre  | to determine which index of overcrowding has strongest association with patient throughput times, ED overcrowding not defined  | hours on bypass                                    | mean hours spent each day on bypass because of admission holds      | ambulance diversion        | input            | predictive                    |
|                                      |  |  | ED daily census                                    | not described   | ED patient volumes overall | input            | predictive                    |

| Study                         | Design                                  | Objectives  | Measures  | Description   | Type of Measure   | Measure Category | Purpose                       |
|-------------------------------|---|---|---|---|-------------------|------------------|-------------------------------|
|                               |   |   | number of held admissions   | not described   | access block      | output           | predictive                    |
|                               |   |   | throughput times (1)  | time from physician admit decision to floor transfer  | access block      | output           | discriminative or descriptive |
|                               |   |   | throughput times (2)  | time from triage to physician evaluation  | ED times          | throughput       | discriminative or descriptive |
|                               |   |   | throughput times (3)  | time from triage to discharge   | ED times          | throughput       | discriminative or descriptive |
|                               |   |   | throughput times (4)  | time from triage to transfer to floor bed   | ED times          | throughput       | discriminative or descriptive |
|                               |   |   | throughput times (5)  | time from physician evaluation to admit decision  | ED times          | throughput       | discriminative or descriptive |
| Bayley, <sup>52</sup><br>US   | prospective cohort study, single centre | to determine marginal cost of extended ED LOS for chest pain patients awaiting non-intensive care unit monitored beds, ED overcrowding not defined  | ED LOS  | not described   | ED LOS            | throughput       | predictive                    |
| Bazarian, <sup>53</sup><br>US | before-and-after study, single centre   | to examine impact of reducing ED boarders through use of short-stay in-patient medicine unit on amount of time that treat-and-release patients spend in ED, ED overcrowding not defined   | number of patients in-board (or emergency in-patients)            | mean number per day of admitted patients waiting in ED >8 hours for in-patient bed  | access block      | output           | evaluative                    |
|                               |   |   | ED LOS  | not described   | ED times          | throughput       | evaluative                    |
|                               |   |   | average number of hours spent in ED by treat-and-release patients | throughput interval for patients treated and released after being triaged to adult care section of ED   | ED times          | throughput       | evaluative                    |
|                               |   |   | number of patients who LWBS                                       | not described   | LWBS              | throughput       | evaluative                    |
| Bernstein, <sup>7</sup><br>US | prospective cohort study, single centre | to develop quantitative measure of ED overcrowding and busyness; to examine whether adverse events are more common during periods of peak ED crowding; ED overcrowding not defined, but definitions used in other studies were referenced: periods when ED is on diversion; daily visit totals exceeding certain threshold; all ED beds filled >8 hours daily | Emergency Department Work Index (EDWIN)                           | $\sum n_i \times t_i / (N_a(B_t - B_a))$ where $n_i$ =number of patients present in ED at certain triage category, $t_i$ =triage category (1 to 5, with 5=most acute); $N_a$ = number of attending physicians on duty at given time; $B_t$ =total number of beds, or treatment bays available in ED; $B_a$ =number of admitted patients (holds) in ED | ED administration | throughput       | discriminative or descriptive |

| Study                          | Design                                   | Objectives  | Measures   | Description  | Type of Measure            | Measure Category | Purpose                       |
|--------------------------------|--|---|--|--|----------------------------|------------------|-------------------------------|
|                                |  |   | nurse or physician measurement of ED overcrowding          | “How busy would you say ED is right now”? (5-point Likert scale)   | ED administration          | throughput       | discriminative or descriptive |
| Bindman, <sup>54</sup><br>US   | prospective cohort study, single centre  | to determine whether length of queue at public hospital ED was associated with increased likelihood of patients’ LWBS by physician; ED overcrowding not defined   | ED waiting time  | calculated by subtracting time patient presented to nursing triage desk from time ED physician recorded meeting patient                            | ED times                   | throughput       | predictive                    |
|                                |  |   | patients who LWBS  | patients who LWBS by physician in ED   | LWBS                       | throughput       | discriminative or descriptive |
| Blake, <sup>55</sup><br>Canada | computer simulation model, single centre | to investigate issues contributing to waiting time in ED, ED overcrowding not defined   | proportion of patients waiting before being seen by doctor | percentage of patients assessed within first hour, percentage of patients assessed within 2 hours, percentage of patients assessed within 3+ hours | ED patient waiting volumes | throughput       | predictive                    |
|                                |  |   | mean time to ED assessment                                 | time between patient arrival and first assessment by physician   | ED times                   | throughput       | predictive                    |
|                                |  |   | total patient LOS in ED                                    | not described  | ED times                   | throughput       | predictive                    |
| Boger, <sup>56</sup><br>US     | before-and-after study, single centre    | to evaluate method to access key patient data to decrease LOS in ED ED overcrowding not defined   | waiting time to treatment area                             | number of ED patients waiting in 4-to-6 hour range   | ED times                   | throughput       | evaluative                    |
|                                |  |   | number of patients who LWBS                                | not described  | LWBS                       | throughput       | evaluative                    |
| Bond, <sup>57</sup><br>Canada  | before-and-after study, single centre    | to evaluate whether use of physician- and nurse-staffed assessment room reduced ED waiting times ED overcrowding not defined  | mean waiting time for non-urgent patients                  | not described  | ED times                   | throughput       | evaluative                    |
| Brown, <sup>58</sup><br>US     | prospective cohort study, single centre  | to examine roles of ED patient volume, hospital occupancy, and internal medicine in-patient census in need for ED diversion, ED overcrowding defined as need of ED ambulance diversion (i.e., when capacity to provide emergency care is overwhelmed) | ED ambulance diversion (1)                                 | number of days with ED ambulance diversion (>2 hours or ≤2 hours per day)  | ambulance diversion        | input            | discriminative or descriptive |
|                                |  |   | ED ambulance diversion (2)                                 | number of days with ED ambulance diversion (>4 hours or ≤4 hours per day)  | ambulance diversion        | input            | discriminative or descriptive |
|                                |  |   | ED patient volumes   | not described  | ED patient volumes overall | input            | predictive                    |

| Study                                 | Design                                  | Objectives   | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|---------------------------------------|---|--|--|---|----------------------------|------------------|-------------------------------|
| Browne, <sup>59</sup><br>Australia    | before-and-after study, single centre   | to examine effectiveness of seamless model of management on quality of care for ED patients, ED overcrowding not defined | waiting time   | average waiting time  | ED times                   | throughput       | evaluative                    |
|                                       |   |  | critical care performance  | time to craniotomy for head injuries  | ED times                   | throughput       | evaluative                    |
| Bucheli, <sup>60</sup><br>Switzerland | before-and-after study, single centre   | to assess effects of addition of physician in ED on patients LOS, ED overcrowding not defined                            | ED census  | daily mean of patients visiting ED  | ED patient volumes overall | input            | discriminative or descriptive |
|                                       |   |  | waiting time from ED entry after registration to first medical procedure       | time from ED entry after registration to first specific medical procedure in triage division  | ED times                   | throughput       | evaluative                    |
|                                       |   |  | waiting time from ED entry to start of history taking and physical examination | not described   | ED times                   | throughput       | evaluative                    |
|                                       |   |  | duration of ED patient examination   | time for history taking, physical examination, and first prescriptions by emergency physician   | ED times                   | throughput       | evaluative                    |
|                                       |   |  | time per hour and per physician for activities other than patient examination  | time available for communication with patients, relatives, nurses, admitting physicians, and consultants, for writing discharge letters, and for case-specific literature reading in ED | ED times                   | throughput       | evaluative                    |
|                                       |   |  | total ED LOS   | time from patient ED entry to discharge from ED triage division (ICU, regular in-patient beds, ED in-patient ward, discharge)   | ED times                   | throughput       | evaluative                    |
| Bullard, <sup>61</sup><br>Canada      | retrospective cohort study, multicentre | to examine LWBS trends over 3-year period, ED overcrowding not defined   | number of ED visits  | not described   | ED patient volumes overall | input            | discriminative or descriptive |
|                                       |   |  | number of patients LWBS  | not described   | LWBS                       | throughput       | discriminative or descriptive |
| Cain, <sup>62</sup><br>US             | before-and-after study, single centre   | to evaluate effect of altering pediatric triage criteria on ED triage scoring, and patient waiting                       | number of ED visits  | not described   | ED patient volumes overall | input            | discriminative or descriptive |

| Study                               | Design                                     | Objectives  | Measures   | Description  | Type of Measure     | Measure Category | Purpose                       |
|-------------------------------------|--|---|--|--|---------------------|------------------|-------------------------------|
|                                     |  | times,<br>ED overcrowding not defined   | waiting time to ED examination                                       | not described  | ED times            | throughput       | evaluative                    |
|                                     |  |   | waiting time to ED disposition                                       | not described  | ED times            | throughput       | evaluative                    |
|                                     |  |   | time to floor admission from ED                                      | not described  | ED times            | throughput       | evaluative                    |
|                                     |  |   | time to intensive care unit admission from ED                        | not described  | ED times            | throughput       | evaluative                    |
|                                     |  |   | proportion of patients leaving before examination                    | not described  | LWBS                | throughput       | discriminative or descriptive |
| Cameron, <sup>63</sup><br>Australia | before-and-after study,<br>multicentre     | to review and analyze system effects of emergency enhancement program,<br>ED overcrowding not defined   | number of episodes of ambulance bypass                               | number of 2-hour periods during which ED could not accept patients arriving by ambulance because of patient overload | ambulance diversion | input            | evaluative                    |
|                                     |  |   | proportion of patients receiving attention within threshold time (1) | proportion of patients seen within threshold time (<30 minutes)  | ED patient volumes  | throughput       | evaluative                    |
|                                     |  |   | proportion of patients receiving attention within threshold time (2) | proportion of patients seen within threshold time (<10 minutes)  | ED patient volumes  | throughput       | evaluative                    |
|                                     |  |   | access block   | number of patients waiting >12 hours for admission to hospital from ED   | access block        | output           | evaluative                    |
| Cameron, <sup>64</sup><br>Australia | before-and-after study,<br>multicentre     | to assess multi-component intervention to reduce access block for ED patients while maintaining elective throughput,<br>ED overcrowding not defined | ambulance bypass   | ambulance diversion  | ambulance diversion | input            | evaluative                    |
|                                     |  |   | emergency patients waiting >12 hours for in-patient bed              | number of patients waiting >12 hours in ED to be admitted to hospital-ward bed                                       | access block        | output           | evaluative                    |
| Campbell, <sup>65</sup><br>Canada   | prospective cohort study,<br>single centre | to evaluate contribution of individual emergency physician efficiency to ED overcrowding,<br>ED overcrowding not defined                            | number of patients seen per hour by each physician                   | not described  | ED patient volumes  | throughput       | discriminative or descriptive |
|                                     |  |   | average time from triage to being seen by EP                         | not described  | ED times            | throughput       | discriminative or descriptive |
|                                     |  |   | average time from being seen by nurse to being seen by EP            | not described  | ED times            | throughput       | discriminative or descriptive |
|                                     |  |   | average time from being seen by EP to discharge                      | not described  | ED times            | throughput       | discriminative or descriptive |

| Study                            | Design                                   | Objectives  | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|----------------------------------|--|---|--|---|----------------------------|------------------|-------------------------------|
| Cardin, <sup>66</sup><br>US      | before-and-after study, single centre    | to evaluate effect of multi-faceted intervention to decrease ED overcrowding, or incidence of return visits to ED or hospital ward; ED overcrowding not defined | rate of stretcher occupancy  | not described   | ED patient volumes         | throughput       | evaluative                    |
|                                  |  |   | mean LOS for patients discharged from ED   | not described   | ED times                   | throughput       | evaluative                    |
|                                  |  |   | average LOS of all ED patients   | not described   | ED times                   | throughput       | evaluative                    |
| Chan, <sup>67</sup><br>US        | before-and-after study, single centre    | to evaluate effectiveness of program termed Accelerated Care at Triage for reducing waiting times and overall LOS for ED patients, ED overcrowding not defined  | mean ED LOS  | not described   | ED LOS                     | throughput       | evaluative                    |
|                                  |  |   | waiting time for fast track  | not described   | ED times                   | throughput       | evaluative                    |
|                                  |  |   | ED census  | not described   | ED patient volumes overall | input            | discriminative or descriptive |
| Channan, <sup>68</sup><br>Canada | prospective cohort study, multicentre    | to determine acuity level, reasons, and outcomes of patients who LWBS, ED overcrowding not defined  | median patient arrival in hours before and during arrival of particular individual | not described   | ED patient volumes         | input            | discriminative or descriptive |
|                                  |  |   | median delay to seeing MD  | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                  |  |   | proportion of patients LWBS  | not described   | LWBS or LAMA               | throughput       | discriminative or descriptive |
| Cheung, <sup>69</sup><br>Canada  | retrospective cohort study single centre | to evaluate effectiveness and efficiency of Advance Triage System, ED overcrowding not defined  | total LOS  | overall LOS in ED                                     | ED LOS                     | throughput       | evaluative                    |
|                                  |  |   | LOS after physician assessment   | time from initial physician assessment to disposition | ED times                   | throughput       | evaluative                    |
| Chin, <sup>70</sup><br>US        | computer simulation model, single centre | to estimate effect of physician practices and patient arrival rate on physician utilization and patient waiting time in ED; ED overcrowding not defined         | average waiting time of discharged patients  | not described   | ED times                   | output           | discriminative or descriptive |
|                                  |  |   | maximum waiting time of discharged patients  | not described   | ED times                   | output           | discriminative or descriptive |
|                                  |  |   | queue of patients waiting for examination  | not described   | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                  |  |   | maximum queue of patients waiting for examination                                  | not described   | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                  |  |   | queue of patients waiting for therapy after external tests                         | not described   | ED patient waiting volumes | throughput       | discriminative or descriptive |

| Study                         | Design                                   | Objectives  | Measures  | Description   | Type of Measure            | Measure Category | Purpose                       |
|-------------------------------|--|---|---|---|----------------------------|------------------|-------------------------------|
|                               |  |   | maximum queue of patients waiting for therapy   | not described   | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                               |  |   | mean evaluation time (service time)   | times for initial diagnostic evaluation   | ED times                   | throughput       | discriminative or descriptive |
|                               |  |   | time for treatment or therapy (service time)  | not described   | ED times                   | throughput       | discriminative or descriptive |
|                               |  |   | total charting time (service time)  | not described   | ED times                   | throughput       | discriminative or descriptive |
|                               |  |   | average visit time of discharged patients   | not described   | ED times                   | throughput       | discriminative or descriptive |
|                               |  |   | maximum visit time of discharged patients   | not described   | ED times                   | throughput       | discriminative or descriptive |
| Connelly, <sup>71</sup><br>US | computer simulation model, single centre | to describe development and operation of platform for computer simulation of ED activity; ED overcrowding not defined | patient inter-arrival time  | time between patient arrivals   | ED times                   | input            | discriminative or descriptive |
|                               |  |   | patient treatment time  | total time patient spends in ED from point that he or she is assigned bed in ED to point when he or she is admitted, discharged, or departs | ED times                   | throughput       | discriminative or descriptive |
|                               |  |   | service time  | sum of treatment time and wait time before being assigned ED bed  | ED times                   | throughput       | discriminative or descriptive |
| Cooke, <sup>72</sup><br>UK    | before-and-after study, single centre    | to evaluate effect of separate stream of care for minor injuries on ED waiting times; ED overcrowding not defined     | proportion of patients waiting <30 minutes to see doctor                              | not described   | ED patient waiting volumes | throughput       | evaluative                    |
|                               |  |   | proportion of patients waiting <60 minutes to see doctor                              | not described   | ED patient waiting volumes | throughput       | evaluative                    |
|                               |  |   | waiting time  | time from arrival to time of seeing doctor  | ED times                   | throughput       | evaluative                    |
| Cooke, <sup>73</sup><br>UK    | retrospective cohort study, multicentre  | to assess if total time spent in ED is related to acute-bed occupancy; ED overcrowding not defined                    | proportion of patients spending >4 hours in ED from arrival to admission or discharge | proportion of patients spending >4 hours in ED from arrival to admission or discharge   | ED patient volumes         | throughput       | discriminative or descriptive |

| Study                          | Design                                    | Objectives   | Measures                                      | Description  | Type of Measure            | Measure Category | Purpose                       |
|--------------------------------|---|--|---|--|----------------------------|------------------|-------------------------------|
| Covington, <sup>74</sup><br>US | before-and-after study, single centre     | to evaluate effectiveness of implementation of nurse practitioner-staffed area in ED; ED overcrowding not defined  | number of patients leaving ED                 | average of patients leaving ED per month   | LWBS                       | throughput       | evaluative                    |
| Curry, <sup>75</sup><br>Canada | prospective cohort study, multicentre     | to assess relationship between hospital occupancy and ED LOS; ED overcrowding not defined  | ED LOS  | not described  | ED LOS                     | throughput       | discriminative or descriptive |
|                                |   |  | number of ED visits                           | not described  | ED patient volumes overall | throughput       | discriminative or descriptive |
| Davis, <sup>76</sup><br>US     | retrospective cohort study, single centre | to determine factors that might be associated with prolonged ED LOS; ED overcrowding not defined   | holding time                                  | time from completion of ED work-up until report was called to OR or ICU                          | ED times                   | output           | discriminative or descriptive |
|                                |   |  | total LOS                                     | time from triage until decision made to admit patient (in operating room or intensive care unit) | ED times                   | throughput       | discriminative or descriptive |
|                                |   |  | ED LOS  | time from triage until ED work-up completed  | ED times                   | throughput       | discriminative or descriptive |
| Derlet, <sup>77</sup><br>US    | before-and-after study, single centre     | to assess effect of policy of triaging patients out of ED; ED overcrowding not defined   | patients who LBWS                             | patients who are registered as emergencies but leave ED waiting room before seeing doctor        | LWBS                       | throughput       | evaluative                    |
| Derlet, <sup>78</sup><br>US    | cross-sectional study, single centre      | to determine frequency and factors associated with patient overcrowding in academic ED; ED overcrowding not defined  | frequency of overcrowding per week            | not described  | ED administration          | system           | discriminative or descriptive |
|                                |   |  | incidence of overcrowding                     | percentage of academic ED with overcrowding problems during study period                         | ED administration          | system           | discriminative or descriptive |
| Derlet, <sup>79</sup><br>US    | cross-sectional study, multicentre        | to describe definition, extent, and factors associated with overcrowding in ED as perceived by ED directors; ED overcrowding definitions provided by survey respondents according to number of patients who wait for certain period of time to see physician; when all ED beds are filled for more than certain period per day; when patients are placed in hallways for | annual ED volume                              | not described  | ED patient volumes overall | input            | discriminative or descriptive |
|                                |   |  | patients waiting >30 minutes to see physician | not described  | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                |   |  | patients waiting >60 minutes to see physician | not described  | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                |   |  | all ED beds filled >6 hours per day           | not described  | ED patient volumes         | throughput       | discriminative or descriptive |

| Study                          | Design                                    | Objectives  | Measures  | Description                                   | Type of Measure            | Measure Category | Purpose                       |
|--------------------------------|---|---|---|---|----------------------------|------------------|-------------------------------|
|                                |   | more than certain period per day; when physicians feel rushed for more than certain period per day; when waiting room is filled more than certain period per day  | patients placed in hallways >6 hours per day                          | not described                                 | ED patient volumes         | throughput       | discriminative or descriptive |
|                                |   |   | waiting room filled >6 hours per day                                  | not described                                 | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                |   |   | emergency doctors feel rushed >6 hours per day                        | not described                                 | ED administration          | throughput       | discriminative or descriptive |
| Derlet, <sup>80</sup><br>US    | cross-sectional study, multicentre        | to determine incidence, causes, and effects of overcrowding in ED; ED overcrowding definitions provided by survey respondents according to number of patients who wait for certain period to see physician; when all ED beds are filled for more than certain period per day; when patients placed in hallways for more than certain period per day; when physicians feel rushed for more than certain period per day | ED beds filled >6 hours per day                                       | not described                                 | ED patient volumes         | throughput       | discriminative or descriptive |
|                                |   |   | patients on gurneys in hallways >6 hours per day                      | not described                                 | ED patient volumes         | throughput       | discriminative or descriptive |
|                                |   |   | having 10 patients who have waited >3 hours to see physician in 1 day | not described                                 | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                |   |   | physicians so rushed they may make errors >6 hours per day            | not described                                 | ED administration          | throughput       | discriminative or descriptive |
| DiGiacomo, <sup>81</sup><br>US | prospective cohort study, single centre   | to determine which factors are associated with increased waiting times in ED; ED overcrowding not defined   | number of patients seen in ED   | not described                                 | ED patient volumes overall | throughput       | predictive                    |
|                                |   |   | entire visit time   | time difference between arrival and discharge | ED times                   | throughput       | discriminative or descriptive |
| Dinah, <sup>82</sup><br>UK     | before-and-after study, single centre     | to investigate effect of fast-track scheme on waiting times in ED; ED overcrowding not defined  | waiting time  | mean or median waiting time in ED             | ED times                   | throughput       | evaluative                    |
| Doxzon, <sup>83</sup><br>US    | retrospective cohort study, single centre | to identify and mitigate situations that result in ED overcrowding; ED overcrowding defined as “saturation” reached when ED acuity or volume has reached maximum levels; ED overcrowding meets at least following criteria: increase in ambulance traffic and staging in hallway >10 minutes; patient   | overall ED visit census per year                                      | number of ED visits per year                  | ED patient volumes overall | input            | discriminative or descriptive |
|                                |   |   | hours of ED holds   | not described                                 | ED times                   | output           | discriminative or descriptive |
|                                |   |   | “door to doc” time  | not described                                 | ED times                   | throughput       | discriminative or descriptive |
|                                |   |   | percentage of patients who LWBS                                       | not described                                 | LWBS                       | throughput       | discriminative or descriptive |

| Study                            | Design                                    | Objectives  | Measures   | Description  | Type of Measure            | Measure Category | Purpose                       |
|----------------------------------|---|---|--|--|----------------------------|------------------|-------------------------------|
|                                  |   | arrival to medical screening examination time >45 minutes; >5 patients waiting for triage; >3 patients are ED holds for >4 hours; monitored beds in ED are occupied   |  |  |                            |                  |                               |
| Dunn, <sup>84</sup><br>Australia | retrospective cohort study, single centre | to determine if changes in hospital occupancy would affect ED occupancy and ED waiting time performance; ED overcrowding defined as situation where large number of admitted patients awaiting hospital admission causes ED dysfunction | number of ED admissions  | number of ED admissions per day  | ED patient volumes overall | input            | discriminative or descriptive |
|                                  |   |   | access block each day  | number of times per day where patient requiring hospital admission spends >8 hours in ED | access block               | output           | discriminative or descriptive |
|                                  |   |   | discharge treatment time   | time from arrival to discharge   | ED times                   | output           | discriminative or descriptive |
|                                  |   |   | admission waiting time   | interval between time of admission request and time of discharge from ED                 | ED times                   | output           | discriminative or descriptive |
|                                  |   |   | time of admission request  | time of request for hospital admission   | ED times                   | output           | discriminative or descriptive |
|                                  |   |   | total capacity of the ED   | not described  | ED administration          | throughput       | discriminative or descriptive |
|                                  |   |   | ED occupancy   | (mean LOS in minutes) x (number of patients per day)/1,440                               | ED administration          | throughput       | discriminative or descriptive |
|                                  |   |   | number of times total number of patients in ED equalled or exceeded bed capacity of ED | not described  | ED administration          | throughput       | discriminative or descriptive |
|                                  |   |   | time to admission request  | interval between time seen and time of admission request                                 | ED times                   | throughput       | discriminative or descriptive |
|                                  |   |   | ED waiting time  | interval between time of arrival and time to be seen                                     | ED times                   | throughput       | discriminative or descriptive |
|                                  |   |   | treatment time   | interval between time seen and time of discharge   | ED times                   | throughput       | discriminative or descriptive |
|                                  |   |   | total time in ED   | interval between time of arrival and time of discharge from ED                           | ED times                   | throughput       | discriminative or descriptive |

| Study                             | Design                                  | Objectives  | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|-----------------------------------|---|---|--|---|----------------------------|------------------|-------------------------------|
|                                   |   |   | patients who did not wait for treatment                      | proportion of patients who did not wait to be seen by health professional                                   | LWBS                       | throughput       | discriminative or descriptive |
| Eckstein, <sup>85</sup><br>US     | prospective cohort study, multicentre   | to describe effect of ED crowding on paramedic ambulance availability;<br>ED crowding defined according to number of hours on diversion in ED                                   | number of ED diversion hours                                 | not described   | ambulance diversion        | input            | discriminative or descriptive |
|                                   |   |   | number of ambulance out-of-service incidents                 | number of incidents in which ambulances out of service while waiting to transfer patients to ED gurney      | ambulance diversion        | input            | discriminative or descriptive |
|                                   |   |   | number of out-of-service hours                               | waiting times for paramedics to transfer patient to ED gurney until they are available for another response | ambulance diversion        | input            | discriminative or descriptive |
| Epstein, <sup>86</sup><br>US      | prospective cohort study, single centre | to determine causes of ambulance diversion using input-throughput-output model; to examine each component's contribution to ambulance diversion;<br>ED overcrowding not defined | number of patients in ED waiting room                        | not described   | ED patient waiting volumes | input            | predictive                    |
|                                   |   |   | number of patients under evaluation in ED                    | not described   | ED patient volumes         | throughput       | predictive                    |
|                                   |   |   | number of patients admitted to hospital but physically in ED | not described   | access block               | output           | predictive                    |
|                                   |   |   | ED ambulance diversion                                       | times when ED was on diversion  | ambulance diversion        | input            | discriminative or descriptive |
| Erickson, <sup>87</sup><br>Canada | prospective cohort study, single centre | to assess LOS experienced by patients of ED, and factors that affect LOS;<br>ED overcrowding not defined  | ED volume  | average monthly volume of ED patients   | ED patient volumes overall | input            | discriminative or descriptive |
|                                   |   |   | LOS  | overall average LOS for study period  | ED times                   | throughput       | discriminative or descriptive |
|                                   |   |   | triage time  | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                   |   |   | registration time  | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                   |   |   | time to nursing assessment                                   | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                   |   |   | time to physician assessment                                 | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                   |   |   | turnaround time for laboratory results                       | not described   | ED times                   | throughput       | discriminative or descriptive |

| Study                                | Design                                  | Objectives  | Measures  | Description  | Type of Measure            | Measure Category | Purpose                       |
|--------------------------------------|---|---|---|--|----------------------------|------------------|-------------------------------|
|                                      |   |   | turnaround time for radiological interpretations                  | not described  | ED times                   | throughput       | discriminative or descriptive |
| Espinosa, <sup>88</sup><br>US        | before-and-after study, single centre   | to evaluate effect of re-engineering radiology services in ED; ED overcrowding not defined  | turnaround time   | time of order entry to time of return of films to th ED  | ED times                   | throughput       | evaluative                    |
|                                      |   |   | fast track cycle time   | time spent in fast track   | ED times                   | throughput       | evaluative                    |
|                                      |   |   | time from arrival to treatment                                    | time from patient arrival to evaluation by ED physician  | ED times                   | throughput       | evaluative                    |
|                                      |   |   | overall LOS   | time from arrival to discharge or transport to in-patient bed  | ED times                   | throughput       | evaluative                    |
| Espinosa, <sup>89</sup><br>Spain     | prospective cohort study, single centre | to assess hypothetical linkage between internal pressures in hospital and ED overcrowding; ED overcrowding defined as situation where initial evaluation and treatment are completed, but patients have to remain in first aid area because of lack of capacity in observation area, because there is no place to discharge or to admit them  | patient arrival in ED   | not described  | ED patient volumes overall | input            | discriminative or descriptive |
|                                      |   |   | number of patients located in ED throughout day                   | not described  | ED patient volumes         | throughput       | discriminative or descriptive |
|                                      |   |   | periods of overcrowding   | periods when patients' initial evaluation and treatment completed, but they had to stay in first aid area because of lack of capacity in observation area and because there was no place to discharge or to admit them | ED administration          | system           | discriminative or descriptive |
| Fatovich, <sup>90</sup><br>Australia | prospective cohort study, single centre | to describe experience of ED overcrowding and ambulance bypass; ED overcrowding defined as situation where ED function is impeded primarily because number of patients waiting to be seen, undergoing assessment and treatment, or waiting for departure, exceeds physical or staffing capacity of ED; reached when ED exceeds 100% occupancy, or earlier if there is inadequate staff or other resources | number of episodes of ambulance bypass                            | situation where ED instructs ambulance service to divert ambulances elsewhere, and bypass nearest ED   | ambulance diversion        | input            | discriminative or descriptive |
|                                      |   |   | duration of ambulance bypass episodes                             | not described  | ambulance diversion        | input            | discriminative or descriptive |
|                                      |   |   | entry overload  | overwhelming (>10 attendances per hour) numbers of patients presenting to ED in short time (1 hour)  | ED patient volumes overall | input            | discriminative or descriptive |
|                                      |   |   | mean number of patients awaiting admission during bypass episodes | not described  | ED patient waiting volumes | output           | discriminative or descriptive |

| Study                                    | Design                                | Objectives  | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|--|---------------------------------------|---|--|---|----------------------------|------------------|-------------------------------|
|  |                                       |   | mean number of ED patients during bypass episodes                            | volume of patients in ED when ambulance bypass activated  | ED patient volumes         | throughput       | discriminative or descriptive |
|  |                                       |   | mean number of patients in ED corridors during bypass episodes               | not described   | ED patient volumes         | throughput       | discriminative or descriptive |
|  |                                       |   | mean number of patients waiting to be seen during bypass episodes            | not described   | ED patient waiting volumes | throughput       | discriminative or descriptive |
|  |                                       |   | number of attendances per hour in 2 hours before ambulance bypass activation | not described   | ED patient volumes         | throughput       | discriminative or descriptive |
| Feferman, <sup>91</sup><br>Canada        | before-and-after study, single centre | to describe and evaluate impact of institutional changes to solve problem of overcrowding in ED; ED overcrowding defined as situation where patients have to stay in ED until beds become available | number of times ED closed to patients arriving by ambulance                  | not described   | ambulance diversion        | input            | evaluative                    |
|  |                                       |   | number of visits to ED   | not described   | ED patient volumes overall | input            | discriminative or descriptive |
|  |                                       |   | number of patients waiting in ED for admission                               | not described.  | access block               | output           | evaluative                    |
| Fernandes, <sup>92</sup><br>Canada       | before-and-after study, single centre | to determine whether Continuous Quality Improvement could be used to minimize LOS for fast track patients; ED overcrowding not defined  | ED LOS   | interval from presentation at triage desk to discharge from ED  | ED times                   | throughput       | evaluative                    |
| Fernandes, <sup>93</sup><br>Canada       | before-and-after study, single centre | to determine effect of reducing LOS on number of ED patients who LWBS by physician; ED overcrowding not defined   | LOS  | ED LOS  | ED times                   | throughput       | evaluative                    |
|  |                                       |   | patients who LWBS  | number of ED patients who LWBS by physician   | LWBS                       | throughput       | evaluative                    |
| Fernandez-Moyano, <sup>94</sup><br>Spain | cross-sectional study, single centre  | to evaluate waiting times as factor associated with overcrowding; ED crowding defined as daily patient attendance >75; ED overcrowding defined as attendance >85 patients per day                   | volume of daily attendance at ED   | number of daily visits to ED optimal: ≤75 patient visits per day; crowded: 75 to 85 patient visits per day; overcrowded: >85 patient visits per day | ED patient volumes overall | input            | discriminative or descriptive |
|  |                                       |   | time awaiting to see physician   | interval from ED arrival to seeing physician  | ED times                   | throughput       | predictive                    |
|  |                                       |   | patient waiting time   | time from first medical assessment to discharge   | ED times                   | throughput       | predictive                    |

| Study                         | Design                                   | Objectives  | Measures   | Description   | Type of Measure | Measure Category | Purpose                       |
|-------------------------------|--|---|--|---|-----------------|------------------|-------------------------------|
|                               |  |   | time awaiting laboratory tests   | time from ordering basic supplementary examinations to results  | ED times        | throughput       | predictive                    |
| Fineberg, <sup>95</sup><br>US | computer simulation model, single centre | to describe general model of emergency room operations; to identify factors impeding or facilitating patient flow through ED; ED overcrowding not defined | elapsed time in ED at triage   | time in hours from arrival to triage in medical care area of ED   | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | elapsed time in ED for initial evaluation                                    | time in hours from arrival to initial medical assessment by physician, whether intern, resident, or member of attending staff | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | elapsed time in ED for X-rays  | time in hours from ED arrival to X-rays   | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | elapsed time in ED for laboratory tests                                      | time in hours from ED arrival to order for laboratory tests   | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | elapsed time in ED for consultation  | time in hours from ED arrival to consultation with specialist   | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | elapsed time in ED for re-evaluation   | time in hours from ED arrival to re-evaluation  | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | elapsed time in ED for disposition   | time in hours from ED arrival to disposition  | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | proportion of total patient time in ED spent in triage                       | not described   | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | proportion of total patient time in ED spent in initial evaluation           | not described   | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | proportion of total patient time in ED spent in X-rays                       | not described   | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | proportion of total patient time in ED spent in laboratory tests             | not described   | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | proportion of total patient time in ED spent in consultation with specialist | not described   | ED times        | throughput       | discriminative or descriptive |
|                               |  |   | proportion of total patient time in ED spent in re-evaluation                | not described   | ED times        | throughput       | discriminative or descriptive |

| Study                              | Design                                    | Objectives   | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|------------------------------------|---|--|--|---|----------------------------|------------------|-------------------------------|
|                                    |   |  | proportion of total patient time in ED spent for disposition | not described   | ED times                   | throughput       | discriminative or descriptive |
| Forero, <sup>96</sup><br>Australia | retrospective cohort study, multicentre   | to test effect of triage category, type of hospital, year of presentation, and other variables on access block; ED overcrowding not defined  | access block (definition 1)                                  | delay (from ready for departure to departure time) >4 hours   | access block               | output           | discriminative or descriptive |
|                                    |   |  | time delay   | delay >2 hours  | access block               | output           | discriminative or descriptive |
|                                    |   |  | delay time   | time from ready for departure to departure  | ED times                   | output           | discriminative or descriptive |
|                                    |   |  | access block (definition 2)                                  | total time in ED (from arrival time to departure time) >8 hours   | ED LOS                     | throughput       | discriminative or descriptive |
|                                    |   |  | access block (definition 3)                                  | active treatment and delay time (from medical assessment time to departure time) >8 hours   | ED times                   | throughput       | discriminative or descriptive |
|                                    |   |  | total ED time  | time from arrival to departure from ED  | ED LOS                     | throughput       | discriminative or descriptive |
|                                    |   |  | waiting time   | time from arrival to medical assessment   | ED times                   | throughput       | discriminative or descriptive |
|                                    |   |  | medical assessment time                                      | time from medical assessment to ready for departure   | ED times                   | throughput       | discriminative or descriptive |
| Forster, <sup>97</sup><br>Canada   | retrospective cohort study, single centre | to determine whether hospital occupancy associated with admitted patients' LOS in ED; to determine whether hospital occupancy associated with admission rate; ED overcrowding defined as situation where hospital occupancy exceeds threshold, and patients admitted through ED may not have immediate access to hospital beds | number of daily ED visits                                    | not described   | ED patient volumes overall | input            | discriminative or descriptive |
|                                    |   |  | arrival density index  | measure of how busy ED was when patients arrived in ED; for each patient, number of patients who had arrived in preceding hour was identified; this number averaged for all patients arriving on calendar day | ED patient volumes overall | input            | discriminative or descriptive |
|                                    |   |  | daily ED LOS for admitted patients                           | median LOS for all patients presenting to ED on single day who were subsequently admitted to hospital; interval   | ED LOS                     | throughput       | discriminative or descriptive |

| Study                                   | Design                                  | Objectives   | Measures                                 | Description   | Type of Measure    | Measure Category | Purpose                       |
|---|---|--|--|---|--------------------|------------------|-------------------------------|
|   |   |  |  | between registration in ED and transfer to ward bed   |                    |                  |                               |
|   |   |  | daily consultation rate                  | proportion of ED patients referred to hospital consultants on each day  | ED patient volumes | throughput       | discriminative or descriptive |
| Fromm Jr, <sup>98</sup><br>US           | prospective cohort study, single centre | to investigate patterns of care utilization in ED; to determine if critically ill patients constitute significant component of ED practice; to quantify burden of critically ill patients on ED by examining ED LOS; ED overcrowding not defined | ED LOS                                   | time from arrival in ED until discharge, death, or admission to in-patient unit   | ED times           | throughput       | discriminative or descriptive |
| Fry, <sup>99</sup><br>Australia         | cross-sectional study, multicentre      | to identify characteristics and reasons for patients leaving before medical assessment; ED overcrowding not defined  | patient waiting time                     | not described   | ED times           | throughput       | discriminative or descriptive |
|   |   |  | proportion of patients who did not wait  | patients who had undergone triage assessment and code allocation but subsequently chose to leave before medical assessment                          | LWBS               | throughput       | discriminative or descriptive |
| Fullerton-Gleason, <sup>100</sup><br>US | retrospective cohort study, multicentre | to test hypothesis that temporary ED closures, forced openings, and ambulance drop times would increase over past 3 years; ED overcrowding defined according to number of ambulance drop times   | temporary ED closures                    | number of hours EDs closed each month   | ED administration  | input            | discriminative or descriptive |
|   |   |  | forced openings                          | forced open hours, i.e., required to take patients for 2-hour period, when critical threshold of closed EDs reached (based on predefined algorithm) | ED administration  | input            | discriminative or descriptive |
|   |   |  | ambulance drop times                     | time needed to transfer patient care to ED staff  | ED times           | input            | discriminative or descriptive |
|   |   |  | extra unit hours of ambulance drop times | total number of unit hours used in excess of standard 15 minutes per patient to transfer patient care to ED staff                                   | ED times           | input            | discriminative or descriptive |

| Study                               | Design                                    | Objectives  | Measures  | Description   | Type of Measure    | Measure Category | Purpose                       |
|-------------------------------------|---|---|---|---|--------------------|------------------|-------------------------------|
| Ganapathy, <sup>101</sup><br>US     | prospective cohort study, single centre   | to describe problem of crowding in ED; to describe how transition team affected processes and care in ED; ED overcrowding not defined   | LOS in ED   | not described   | ED times           | throughput       | discriminative or descriptive |
| George, <sup>102</sup><br>UK        | controlled trial, single centre           | to compare formal nurse triage with informal prioritization process for waiting times and patient satisfaction; ED overcrowding not defined   | waiting times   | time between first attendance in department and obtaining medical attention | ED times           | throughput       | evaluative                    |
| Grafstein, <sup>103</sup><br>Canada | retrospective cohort study, single centre | to compare baseline characteristics, ED utilization, and adverse outcomes in patient with waiting room and hallway care versus those triaged to acute-care bed; ED overcrowding not defined | ED LOS  | not described   | ED LOS             | throughput       | evaluative                    |
|                                     |   |   | number of patients who LWBS   | not described   | LWBS               | throughput       | evaluative                    |
|                                     |   |   | number of patients who LAMA   | not described   | LWBS               | throughput       | evaluative                    |
| Grafstein, <sup>104</sup><br>Canada | retrospective cohort study, single centre | to compare baseline characteristics, ED utilization, and adverse outcomes in patients with waiting room care versus those triaged to acute-care bed; ED overcrowding not defined            | ED LOS  | not described   | ED LOS             | throughput       | discriminative or descriptive |
|                                     |   |   | number of patients who had their entire care in waiting room                                    | not described   | ED patient volumes | throughput       | discriminative or descriptive |
|                                     |   |   | number of patients who LWBS or who LAMA   | not described   | LWBS               | throughput       | discriminative or descriptive |
| Grant, <sup>105</sup><br>Australia  | before-and-after study, single centre     | to evaluate whether rapid assessment team can reduce ED waiting times, and improve performance of clinical indicator waiting time relative to triage category; ED overcrowding not defined  | number of patients seen within waiting time appropriate to National Triage Scale classification | not described   | ED patient volumes | throughput       | evaluative                    |
|                                     |   |   | median waiting time   | time between registration at triage desk and time of assessment by doctor   | ED times           | throughput       | evaluative                    |
|                                     |   |   | LOS   | time between registration at triage desk and time of leaving ED             | ED times           | throughput       | evaluative                    |
|                                     |   |   | number of patients who did not wait to see doctor   | not described   | LWBS               | throughput       | evaluative                    |

| Study                            | Design                                   | Objectives   | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|----------------------------------|--|--|--|---|----------------------------|------------------|-------------------------------|
| Hall, <sup>106</sup><br>Canada   | before-and-after study, single centre    | to determine impact of triaging Canadian Triage and Acuity Scale (CTAS) category 5 and some category 4 patients through fast track system; ED overcrowding not defined           | ED census  | not described   | ED patient volumes overall | input            | discriminative or descriptive |
|                                  |  |  | LOS  | not described   | ED LOS                     | throughput       | evaluative                    |
|                                  |  |  | number of patients LWBS                                      | not described   | LWBS                       | throughput       | evaluative                    |
| Hampers, <sup>107</sup><br>US    | prospective cohort study, single centre  | to examine differences in evaluation, management, and outcomes for patients seen in on-site “fast track” versus main ED; ED overcrowding not defined                             | LOS  | time from presentation to triage desk to discharge from ED of fast track area             | ED times                   | throughput       | evaluative                    |
| Handyside, <sup>108</sup><br>UK  | computer simulation model, single centre | to describe method to simulate emergency bed occupancy, and allowing comparison of effects on bed occupancy of rotational admission schedules in ED; ED overcrowding not defined | bed occupancy  | not described   | ED administration          | throughput       | discriminative or descriptive |
|                                  |  |  | duration of patient stay                                     | not described   | ED times                   | throughput       | predictive                    |
| Heckerling, <sup>109</sup><br>US | prospective cohort study, single centre  | to quantify factors contributing to long patient visit times; ED overcrowding not defined  | time to admission  | time decision made to admit patient to hospital or to discharge patient from ED           | ED times                   | output           | discriminative or descriptive |
|                                  |  |  | time from entry into ED until initial contact with physician | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                  |  |  | turnaround times for laboratory tests                        | time laboratory tests sent and results received   | ED times                   | throughput       | discriminative or descriptive |
|                                  |  |  | turnaround times for radiographic studies                    | time radiographic studies ordered and results received                                    | ED times                   | throughput       | discriminative or descriptive |
|                                  |  |  | length of emergency room stay                                | proportion of patients completing ED visits in <2.5, <3.5, <5.0 hours                     | ED times                   | throughput       | discriminative or descriptive |
| Howell, <sup>110</sup><br>US     | before-and-after study, single centre    | to compare patient waiting times and quality assurance parameters with two methods of physician staffing; ED overcrowding not defined  | ED census  | average daily census  | ED patient volumes overall | input            | discriminative or descriptive |
|                                  |  |  | number of patients waiting >1 hour for disposition from ED   | number of patients waiting >1 hour to be seen by provider after being signed in on ED log | ED patient waiting volumes | output           | evaluative                    |
|                                  |  |  | number of patients waiting >2 hours for disposition          | number of patients waiting >2 hours from time they  | ED patient waiting         | output           | evaluative                    |

| Study                           | Design                                       | Objectives   | Measures  | Description   | Type of Measure            | Measure Category | Purpose                       |
|---------------------------------|--|--|---|---|----------------------------|------------------|-------------------------------|
|                                 |  |  | from ED   | signed into ED until disposition made from ED   | volumes                    |                  |                               |
|                                 |  |  | waiting time to be seen by physician                          | number of minutes waited by each patient to be seen by provider after signing in                          | ED times                   | throughput       | evaluative                    |
|                                 |  |  | total time from entry to ED until disposition                 | number of minutes waited after sign-in by each patient until disposition from ED                          | ED times                   | throughput       | evaluative                    |
|                                 |  |  | number of patients who left without being seen by a physician | not described   | LWBS                       | throughput       | evaluative                    |
| Howell, <sup>111</sup><br>US    | before-and-after study,<br>single centre     | to assess implementation of new direct admission system based on telephone consultation between ED physicians and in-house hospital staff;<br>ED overcrowding not defined  | admission cycle time  | time from ED decision to admit patient until time patient arrived on medical service for transfer to ward | ED times                   | throughput       | evaluative                    |
| Hu, <sup>112</sup><br>Taiwan    | prospective cohort study,<br>single centre   | to demonstrate that use of computer in ED to store and analyze information can provide insight into ways of improving efficiency of ED operation, particularly regarding slowing of patient flow in ED;<br>ED overcrowding not defined | total ED patient numbers                                      | not described   | ED patient volumes overall | input            | discriminative or descriptive |
|                                 |  |  | waiting time from registration to seeing physician            | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                 |  |  | disposition time  | waiting time from registration to disposition   | ED times                   | throughput       | discriminative or descriptive |
|                                 |  |  | examination time  | time from initiation to conclusion of examination   | ED times                   | throughput       | discriminative or descriptive |
| Innes, <sup>113</sup><br>Canada | retrospective cohort study,<br>single centre | to determine impact of ED computerized physician order entry system on ED LOS;<br>ED overcrowding not defined  | number of admitted patients held in ED                        | not described   | access block               | output           | evaluative                    |
|                                 |  |  | stretcher time  | time waiting for in-patient beds  | access block               | output           | evaluative                    |
|                                 |  |  | ED LOS  | time from registration to discharge   | ED LOS                     | throughput       | evaluative                    |
|                                 |  |  | number of patients treated in hallways                        | not described   | ED patient volumes         | throughput       | evaluative                    |
| Innes, <sup>114</sup><br>Canada | before-and-after study,<br>single centre     | to evaluate whether change to ED physician order entry would reduce ED LOS;<br>ED overcrowding not defined   | number of admitted patients held in ED                        | mean daily number of admitted patients held in ED   | access block               | output           | evaluative                    |
|                                 |  |  | ED LOS for discharged patients                                | not described   | ED LOS                     | throughput       | evaluative                    |

| Study                             | Design                                     | Objectives   | Measures                                     | Description  | Type of Measure            | Measure Category | Purpose    |
|-----------------------------------|--|--|--|--|----------------------------|------------------|------------|
|                                   |  |  | number of waiting room patients at ED        | not described  | ED patient waiting volumes | throughput       | evaluative |
| Kelen, <sup>115</sup><br>US       | before-and-after study, single centre      | to determine impact of in-patient ED-managed acute care unit on ED overcrowding, and use of ambulance diversion<br>ED overcrowding not defined   | frequency of ambulance diversion             | frequency of emergency medical services diversion.<br>mean hours per 100 patients  | ambulance diversion        | input            | evaluative |
|                                   |  |  | ambulance diversion                          | mean hours in ambulance diversion per 100 patients                                 | ambulance diversion        | input            | evaluative |
|                                   |  |  | patient volumes                              | daily patient volumes (number of patients at ED per day)                           | ED patient volumes overall | input            | evaluative |
|                                   |  |  | number of patients who LWBS                  | registered ED patients who LWBS  | LWBS                       | throughput       | evaluative |
| Kilic, <sup>116</sup><br>Turkey   | controlled trial, single centre            | to determine effectiveness of “fast tracking” in academic ED during period of limited resources and space constraints;<br>ED overcrowding not defined  | ED LOS                                       | time from admission to discharge   | ED times                   | throughput       | evaluative |
| Klassen, <sup>117</sup><br>Canada | randomized controlled trial, single centre | to determine whether triage nurses using Brand protocol would order fewer radiographs than would physicians carrying out standard practice procedures; to determine whether having triage nurses order radiographs could reduce total patient waiting time in ED;<br>ED overcrowding not defined | total time spent in ED                       | time between arrival at ED and referral to orthopedic surgery service or discharge | ED times                   | throughput       | evaluative |
| Krakau, <sup>118</sup><br>Sweden  | before-and-after study, single centre      | to evaluate how addition of general practitioner surgery influences utilization of ED<br>ED overcrowding not defined   | ED patient volume                            | number of ED visits  | ED patient volumes overall | input            | evaluative |
|                                   |  |  | average waiting time for non-urgent patients | not described  | ED times                   | throughput       | evaluative |
|                                   |  |  | average waiting time for urgent patients     | not described  | ED times                   | throughput       | evaluative |
| Kyriacou, <sup>119</sup><br>US    | before-and-after study, single centre      | to calculate main ED patient care intervals, to identify areas of inefficiency; to measure effect of ED and in-patient bed availability  | daily patient census                         | not described  | ED patient volumes overall | input            | predictive |

| Study                      | Design                                   | Objectives   | Measures  | Description   | Type of Measure  | Measure Category  | Purpose                       |                               |
|----------------------------|--|--|---|---|--|-------------------|-------------------------------|-------------------------------|
|                            |  | on patient flow; to quantitatively assess effects of administrative interventions aimed at improving efficiency; to evaluate relationship between waiting times to see physician and number of patients who LWBS by physician; ED overcrowding not defined | time from disposition order to patient discharge from ED                | not described   | ED times   | output            | evaluative                    |                               |
|                            |  |  | total LOS   | time from triage presentation to patient discharge from ED      | ED times   | throughput        | evaluative                    |                               |
|                            |  |  |   | time from triage presentation to completion of registration     | not described  | ED times          | throughput                    | evaluative                    |
|                            |  |  |   | time from completion of registration to ED treatment area entry | not described  | ED times          | throughput                    | evaluative                    |
|                            |  |  |   | ratio of physicians to waiting room patient                     | not described  | ED administration | throughput                    | predictive                    |
|                            |  |  |   | waiting time  | interval from ED arrival to first contact with physician or mid-level provider | ED times          | throughput                    | discriminative or descriptive |
| Lane, <sup>123</sup><br>UK | computer simulation model, single centre | to explore factors that contribute to long waiting times for emergency admissions; ED overcrowding not defined   | average number of emergency patients arriving in ED in hourly intervals | not described   | ED patient volumes overall   | input             | discriminative or descriptive |                               |
|                            |  |  | average time to ED doctor consultation in hours                         | time from registration to consultation with ED doctor           | ED times   | throughput        | discriminative or descriptive |                               |
|                            |  |  | average time to decision to admit in hours                              | time from registration to decision to admit                     | ED times   | throughput        | discriminative or descriptive |                               |
|                            |  |  | total waiting time  | not described   | ED times   | throughput        | discriminative or descriptive |                               |
|                            |  |  | time from registration to admission to wards                            | not described   | ED times   | throughput        | discriminative or descriptive |                               |
|                            |  |  | time from decision to admit until patient leaves ED for ward admission  | not described   | ED times   | output            | discriminative or descriptive |                               |
|                            |  |  | time from consultation with specialty doctor until decision to admit    | not described   | ED times   | throughput        | discriminative or descriptive |                               |
|                            |  |  | time from referral until consultation by specialty doctor               | not described   | ED times   | throughput        | discriminative or descriptive |                               |
|                            |  |  | time from consultation until referral to specialty doctor               | not described   | ED times   | throughput        | discriminative or descriptive |                               |

| Study                                  | Design                                  | Objectives   | Measures  | Description   | Type of Measure | Measure Category | Purpose                       |
|--|---|--|---|---|-----------------|------------------|-------------------------------|
| Lau, <sup>124</sup><br>Hong Kong       | before-and-after study, single centre   | to determine effect of small team consultation system on patients' waiting time in ED; ED overcrowding not defined   | waiting time  | interval between time patient registers and time patient seen by doctor                           | ED times        | throughput       | evaluative                    |
| Lee-Lewandrowski, <sup>125</sup><br>US | before-and-after study, single centre   | to investigate impact of point-of-care testing satellite laboratory in ED; ED overcrowding not defined   | ED LOS  | time from registration in triage to time of discharge or transport to floor for admitted patients | ED times        | throughput       | evaluative                    |
|  |   |  | time specimen received in central laboratory until results posted in hospital computer for review | interval between time patient registers and time patient seen by doctor                           | ED times        | throughput       | evaluative                    |
| Liew, <sup>126</sup><br>Australia      | retrospective cohort study, multicentre | to examine association between ED LOS and in-patient LOS; access block used as proxy measure of ED overcrowding; access block defined as LOS >8 hours                    | in-patient LOS  | time from ED presentation to discharge from hospital  | ED times        | throughput       | discriminative or descriptive |
|  |   |  | ED LOS  | time from ED presentation to transfer to ward   | ED times        | throughput       | predictive                    |
| Liptak, <sup>127</sup><br>US           | prospective cohort study, single centre | to document and analyze waiting that patients undergo in pediatric ED; to identify areas that could be modified to decrease patient waiting; ED overcrowding not defined | waiting time to be admitted   | not described   | ED times        | output           | discriminative or descriptive |
|  |   |  | mean time for registration (time in waiting room)   | not described   | ED times        | throughput       | discriminative or descriptive |
|  |   |  | mean time for triage (time in waiting room)   | not described   | ED times        | throughput       | discriminative or descriptive |
|  |   |  | time from registration to entering examining room   | not described   | ED times        | throughput       | discriminative or descriptive |
|  |   |  | time spent waiting in examining room for initial physician evaluation                             | not described   | ED times        | throughput       | discriminative or descriptive |
|  |   |  | total time spent in ED  | not described   | ED times        | throughput       | discriminative or descriptive |
|  |   |  | waiting time for laboratory test results  | not described   | ED times        | throughput       | discriminative or descriptive |
|  |   |  | waiting time to go to radiology department  | not described   | ED times        | throughput       | discriminative or descriptive |
|  |   |  | waiting time for physician to read roentgenogram  | not described   | ED times        | throughput       | discriminative or descriptive |
|  |   |  | waiting time for consultant   | not described   | ED times        | throughput       | discriminative or descriptive |

| Study                           | Design                                    | Objectives   | Measures   | Description   | Type of Measure     | Measure Category | Purpose                       |
|---------------------------------|---|--|--|---|---------------------|------------------|-------------------------------|
|                                 |   |  | time spent receiving medical care                  | not described   | ED times            | throughput       | discriminative or descriptive |
|                                 |   |  | number of patients who LWBS                        | not described   | LWBS                | throughput       | discriminative or descriptive |
| Liu, <sup>128</sup><br>US       | retrospective cohort study, single centre | to compare measurements of ED patient flow during periods of acute ED overcrowding and times of normal patient volume; ED overcrowding defined according to ED critical bed status (CBS); CBS defined by ED policy as department overwhelmed by triage level 1 and 2 patients, inadequate stretcher space for additional critical or stretcher patients, or reasonable anticipation of multiple injured patients | time on critical bed status                        | not described   | ED times            | throughput       | discriminative or descriptive |
|                                 |   |  | time from patient check-in to room                 | interval from first time stamp on triage entry log to transport and placement into treatment room                   | ED times            | throughput       | discriminative or descriptive |
|                                 |   |  | time from room to physician                        | time from placement into treatment room to seeing physician (time of assessment), or to get physician orders        | ED times            | throughput       | discriminative or descriptive |
|                                 |   |  | time from orders to first intervention             | time from getting physician orders to first intervention (blood draw, imaging, or consultant called)                | ED times            | throughput       | discriminative or descriptive |
|                                 |   |  | time from first intervention to disposition        | time from first intervention to physical discharge from department performed by nurse and recorded in nursing notes | ED times            | throughput       | discriminative or descriptive |
|                                 |   |  | LOS  | not described   | ED times            | throughput       | discriminative or descriptive |
|                                 |   |  |  |   |                     |                  |                               |
| Mallett, <sup>129</sup><br>UK   | before-and-after study, single centre     | to investigate effect of triage system on waiting times of ED attenders; ED overcrowding not defined   | time taken to see doctor                           | time taken from arrival to seeing doctor  | ED times            | throughput       | evaluative                    |
|                                 |   |  | time taken to see health care professional (nurse) | time taken from arrival to seeing nurse   | ED times            | throughput       | evaluative                    |
|                                 |   |  | time to be seen by triage assessor                 | not described   | ED times            | throughput       | evaluative                    |
|                                 |   |  | time spent in ED                                   | not described   | ED times            | throughput       | evaluative                    |
| McAfee, <sup>130</sup><br>US    | before-and-after study, single centre     | to analyze effect of computerized order entry system on ED LOS; ED overcrowding not defined  | ED LOS   | time of patient triage to time that patient physically left ED  | ED LOS              | throughput       | evaluative                    |
| McConnell, <sup>131</sup><br>US | retrospective cohort study,               | to determine effect of ED crowding and ambulance   | ambulance diversion                                | not described   | ambulance diversion | input            | discriminative or descriptive |

| Study                          | Design                                    | Objectives  | Measures  | Description  | Type of Measure            | Measure Category | Purpose                       |
|--------------------------------|---|---|---|--|----------------------------|------------------|-------------------------------|
|                                | single centre                             | diversion on times spent in waiting room and in ED examination rooms; ED overcrowding not defined   | diversion because of ED overload                | not described  | ambulance diversion        | input            | predictive                    |
|                                |   |   | diversion because of lack of ICU beds           | not described  | ambulance diversion        | input            | predictive                    |
|                                |   |   | time in waiting room                            | not described  | ED times                   | throughput       | discriminative or descriptive |
|                                |   |   | time in examination room for patients sent home | not described  | ED times                   | throughput       | discriminative or descriptive |
|                                |   |   | time in examination room for admitted patients  | not described  | ED times                   | throughput       | discriminative or descriptive |
|                                |   |   | total number of patients in ED                  | not described  | ED patient volumes overall | input            | predictive                    |
|                                |   |   | patients who LWBS by physician                  | not described  | LWBS                       | throughput       | discriminative or descriptive |
|                                |   |   | patients who LAMA                               | not described  | LAMA                       | throughput       | discriminative or descriptive |
| McMullan, <sup>132</sup><br>US | retrospective cohort study, single centre | to determine how ED volume and acuity influence number of patients leaving ED without treatment; ED overcrowding not defined                                | ED volume                                       | not described  | ED patient volumes overall | throughput       | predictive                    |
|                                |   |   | patients leaving without treatment              | number of patients who leave ED without being seen and treated by physician, includes patients who LAMA, those who left before assessment, treatment or discharge planning completed, or those who did not answer multiple calls in waiting area | LWBS                       | throughput       | discriminative or descriptive |
| Miro, <sup>6</sup><br>Spain    | prospective cohort study, single centre   | to assess influence of overcrowding on health care quality provided by ED; ED overcrowding defined as number of daily visits between 100 and 120 or greater | number of overall ED visits                     | total number of visits per week  | ED patient volumes overall | input            | predictive                    |

| Study                         | Design                                  | Objectives   | Measures  | Description  | Type of Measure            | Measure Category | Purpose                       |
|-------------------------------|---|--|---|--|----------------------------|------------------|-------------------------------|
| Miro, <sup>133</sup><br>Spain | prospective cohort study, single centre | to determine relative effect of external and internal factors on ED efficiency; ED overcrowding defined as accumulation of patients to be seen at ED | number of patients waiting for visit                              | not described  | ED patient waiting volumes | input            | discriminative or descriptive |
|                               |   |  | external pressure   | number of patients arriving at ED during last 3 hours                            | ED patient volumes overall | input            | predictive                    |
|                               |   |  | internal pressure: hospital-related factors outside ED            | number of patients waiting for admission beds                                    | access block               | output           | predictive                    |
|                               |   |  | internal pressure: non-ED and non-hospital related factors        | number of patients waiting for relatives, social worker, or ambulance            | ED patient waiting volumes | output           | predictive                    |
|                               |   |  | internal ED pressure  | number of patients staying in ED after beginning visit                           | ED patient volumes         | throughput       | predictive                    |
|                               |   |  | internal pressure: ED-related factors (1)                         | number of patients waiting to see doctor   | ED patient waiting volumes | throughput       | predictive                    |
|                               |   |  | internal pressure: ED-related factors (2)                         | number of patients being attended at measurement time                            | ED patient volumes         | throughput       | predictive                    |
|                               |   |  | internal pressure: ED-related factors (3)                         | number of patients waiting for laboratory or X-ray results                       | ED patient waiting volumes | throughput       | predictive                    |
|                               |   |  | internal pressure: ED-related factors (4)                         | number of patients waiting for evolution of clinical status                      | ED patient waiting volumes | throughput       | predictive                    |
|                               |   |  | internal pressure: ED-hospital inter-relation-related factors (1) | number of patients waiting for further tests independent of ED                   | ED patient waiting volumes | throughput       | predictive                    |
|                               |   |  | internal pressure: ED-hospital inter-relation-related factors (2) | number of patients waiting for assessment by specialist external to ED           | ED patient waiting volumes | throughput       | predictive                    |
|                               |   |  | mean waiting time for visit                                       | mean waiting time of 3 patients who accumulated longest waiting times to be seen | ED times                   | throughput       | predictive                    |
| Miro, <sup>134</sup><br>Spain | prospective cohort study, single centre | to evaluate whether quality markers used to assess outcomes of emergency care modified by ED overcrowding;   | number of weekly ED visits  | number of patients registered at ED per week                                     | ED patient volumes overall | throughput       | discriminative or descriptive |

| Study                         | Design                                | Objectives  | Measures  | Description   | Type of Measure            | Measure Category | Purpose                       |
|-------------------------------|---------------------------------------|---|---|---|----------------------------|------------------|-------------------------------|
|                               |                                       | ED crowding defined as volume of ED patients between 701 and 800 per week; ED overcrowding defined as a volume of ED patients >800 per week   | number of patients who leave ED without being seen by physician         | number of patients who left ED after registering in ED but before being examined by physician                   | LWBS                       | throughput       | predictive                    |
| Miro, <sup>135</sup><br>Spain | before-and-after study, single centre | to evaluate internal factors influencing patient flow, effectiveness, and overcrowding in ED; to evaluate effects of ED reorganization on these indicators; ED overcrowding defined as any 3-hour period with more than certain number (15 or 24) of patient arrivals at ED; lack of capacity in treatment and observation area reduced flow of patients into initial assessment area | rate of patient arrival at ED   | number of arrivals per hour at ED for study period  | ED patient volumes overall | input            | discriminative or descriptive |
|                               |                                       |   | number of patients waiting after being seen                             | number of patients waiting for admission or discharge after being seen in treatment and observation areas       | access block               | output           | evaluative                    |
|                               |                                       |   | number of patients waiting to go to in-hospital bed (patient flow)      | not described   | access block               | output           | evaluative                    |
|                               |                                       |   | number of patients waiting to find in-hospital bed (patient flow)       | not described   | access block               | output           | evaluative                    |
|                               |                                       |   | number of patients waiting for investigations outside ED (patient flow) | not described   | ED patient waiting volumes | output           | evaluative                    |
|                               |                                       |   | number of patients waiting for relatives (patient flow)                 | not described   | ED patient waiting volumes | output           | evaluative                    |
|                               |                                       |   | number of patients waiting for social worker (patient flow)             | not described   | ED patient waiting volumes | output           | evaluative                    |
|                               |                                       |   | number of patients waiting for ambulance (patient flow)                 | not described   | ED patient waiting volumes | output           | evaluative                    |
|                               |                                       |   | number of patients waiting to be seen                                   | patients waiting to enter initial assessment area cubicle for medical assistance after initial triage interview | ED patient waiting volumes | throughput       | evaluative                    |
|                               |                                       |   | number of patients being seen   | number of patients being seen in initial assessment area  | ED patient volumes         | throughput       | evaluative                    |

| Study  | Design                                     | Objectives   | Measures  | Description   | Type of Measure            | Measure Category | Purpose    |
|--|--|--|---|---|----------------------------|------------------|------------|
|  |  |  | number of patients waiting for doctor (patient flow)  | not described   | ED patient waiting volumes | throughput       | evaluative |
|  |  |  | number of patients waiting for test results (patient flow)                                  | not described   | ED patient waiting volumes | throughput       | evaluative |
|  |  |  | number of patients waiting for outcome (patient flow)                                       | not described   | ED patient waiting volumes | throughput       | evaluative |
|  |  |  | number of patients waiting for specialist (patient flow)                                    | not described   | ED patient waiting volumes | throughput       | evaluative |
|  |  |  | waiting time to be seen   | mean of waiting times of 3 patients waiting to enter initial assessment area cubicle for longest time (with highest cumulative waiting times) | ED times                   | throughput       | evaluative |
|  |  |  | number of patients who LWBS by physician  | number of patients who LWBS by physician per hour   | LWBS                       | throughput       | evaluative |
| Murray, <sup>136</sup><br>Canada               | randomized controlled trial, single centre | to evaluate whether introduction of point-of-care testing can result in reduced lengths of stay in ED; ED overcrowding not defined | ED LOS  | interval between triage and disposition from ED   | ED times                   | throughput       | evaluative |
| NHS Modernisation Agency, <sup>137</sup><br>UK | before-and-after study, multicentre        | to describe effects of composite intervention to improve flow of emergency admissions; ED overcrowding not defined                 | number of >12-hour trolley waits  | not described   | ED patient waiting volumes | output           | evaluative |
|  |  |  | average number of 4-hour to 12-hour trolley waits   | number of patients who waited between 4 and 12 hours on trolleys  | ED patient waiting volumes | output           | evaluative |
|  |  |  | percentage of ED admissions waiting >4 hours  | proportion of patients waiting >4 hours for admission   | access block               | output           | evaluative |
|  |  |  | percentage of patients waiting over target waiting time from decision to admit to admission | not described   | access block               | output           | evaluative |

| Study                         | Design                                  | Objectives   | Measures   | Description  | Type of Measure            | Measure Category | Purpose                       |
|-------------------------------|---|--|--|--|----------------------------|------------------|-------------------------------|
|                               |   |  | percentage of patients waiting over target waiting time for ED triage                          | not described  | ED patient waiting volumes | throughput       | evaluative                    |
|                               |   |  | percentage of patients waiting over target waiting time from triage to examination by ED staff | not described  | ED patient waiting volumes | throughput       | evaluative                    |
|                               |   |  | percentage of patients waiting over target waiting time from examination to decision to admit  | not described  | ED patient waiting volumes | throughput       | evaluative                    |
| Partovi, <sup>138</sup><br>US | controlled trial, single centre         | to determine whether faculty triage activities can shorten ED LOS;<br>ED overcrowding not defined  | total patients registered per day  | not described  | ED patient volumes overall | throughput       | predictive                    |
|                               |   |  | ED LOS   | time from triage to discharge  | ED times                   | throughput       | evaluative                    |
|                               |   |  | patients who LWBS  | number of patients who failed to respond to $\geq 3$ calls to be brought into ED evaluation and treatment area | LWBS                       | throughput       | evaluative                    |
| Paulson, <sup>139</sup><br>US | before-and-after study, single centre   | to compare waiting time and number of patients who LWBS between triage systems that use nurses versus unlicensed assistive personnel;<br>ED overcrowding not defined | waiting time   | time from triage to treatment  | ED times                   | throughput       | evaluative                    |
|                               |   |  | triage time  | time from sign-in to triage  | ED times                   | throughput       | evaluative                    |
|                               |   |  | treatment time   | time from treatment to disposition   | ED times                   | throughput       | evaluative                    |
|                               |   |  | number of patients who LWBS  | not described  | LWBS                       | throughput       | evaluative                    |
| Purnell, <sup>140</sup><br>US | cross-sectional study, multicentre      | to describe systematically characteristics that address waiting time in ED;<br>ED overcrowding not defined   | waiting time   | time for client to be seen by health care practitioner and to begin treatment beyond first aid                 | ED times                   | throughput       | discriminative or descriptive |
|                               |   |  | turnaround time  | waiting time for laboratory to draw blood or for patients to be transported to X-ray                           | ED times                   | throughput       | discriminative or descriptive |
| Reeder, <sup>141</sup><br>US  | prospective cohort study, single centre | to measure physician's and nursing staff's objective assessments of ED overcrowding;<br>to compare agreement of this assessment between physician                    | bed ratio  | (number of patients in ED+predicted arrivals–predicted departures)orED spaces                                  | ED administration          | throughput       | discriminative or descriptive |

| Study                                | Design                                    | Objectives  | Measures  | Description   | Type of Measure            | Measure Category | Purpose                       |
|--------------------------------------|---|---|---|---|----------------------------|------------------|-------------------------------|
|                                      |   | and nursing staff; to compare Real-Time Emergency Analysis of Demand Indicators (READI) scores with ED staff perceptions of ED demand and capacity; ED overcrowding defined as demand value [(bed ratio+provider ratio) x acuity ratio]>7   | acuity ratio                                      | $\sum(\text{triage category}) (\text{number at each category})/\text{number of patients}$ | ED administration          | throughput       | discriminative or descriptive |
|                                      |   |   | demand value                                      | (bed ratio+provider ratio) x acuity ratio   | ED administration          | throughput       | discriminative or descriptive |
|                                      |   |   | provider ratio                                    | arrivals per hour $\sum$ patients seen per hour for each physician                        | ED administration          | throughput       | discriminative or descriptive |
|                                      |   |   | staff perception of ED demand                     | perception on whether demands on current resources exceed available resources             | ED administration          | throughput       | discriminative or descriptive |
| Rehmani, <sup>142</sup> Pakistan     | retrospective cohort study, single centre | to quantify extent of ED overcrowding; to analyze some specific causes of ED overcrowding and possible solutions; ED overcrowding present when delay in transfer of admitted patients from ED to hospital bed is >4 hours   | number of patients who stay >6 hours              | not described   | ED patient volumes         | throughput       | discriminative or descriptive |
| Richards, <sup>3</sup> US            | cross-sectional study, multicentre        | to survey directors of ED on their opinions of extent and factors associated with ED overcrowding; ED overcrowding definitions provided by survey respondents according to number of patients who wait for certain period to see physician; when all ED beds are filled for more than certain period per day; when patients placed in hallways for more than certain period per day; when physicians feel rushed for more than certain period per day | patients wait >30 minutes to see physician        | not described   | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                      |   |   | patients wait >60 minutes to see physician        | not described   | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                      |   |   | all beds filled >6 hours per day                  | not described   | ED patient volumes         | throughput       | discriminative or descriptive |
|                                      |   |   | patients placed in hallways >6 hours per day      | not described   | ED patient volumes         | throughput       | discriminative or descriptive |
|                                      |   |   | waiting room filled >6 hours per day              | not described   | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                      |   |   | emergency physicians felt rushed >6 hours per day | not described   | ED administration          | throughput       | discriminative or descriptive |
| Richardson, <sup>143</sup> Australia | retrospective cohort study, single centre | to determine if association exists between daily access block and ED performance;   | number of access block cases                      | number of access block cases per day  | access block               | output           | discriminative or descriptive |
|                                      |   |   | waiting time                                      | time from arrival to seeing   | ED times                   | throughput       | predictive                    |

| Study                                   | Design                                    | Objectives  | Measures                      | Description   | Type of Measure            | Measure Category | Purpose                       |
|---|---|---|-------------------------------|---|----------------------------|------------------|-------------------------------|
|   |   | ED overcrowding defined according to presence of access block, which is referred as situation where ED patients requiring in-patient care are unable to gain access to hospital wards for prolonged periods   |                               | doctor  |                            |                  |                               |
|   |   |   | assessment time               | time from seeing doctor to leaving ED   | ED times                   | throughput       | predictive                    |
|   |   |   | access block                  | assessment time >8 hours for any case leading to in-patient admission                                     | ED times                   | throughput       | discriminative or descriptive |
| Richardson, <sup>144</sup><br>Australia | retrospective cohort study, single centre | to investigate relationship between access block in ED and in-patient LOS; ED overcrowding not defined  | access block                  | total time from arrival to transfer from ED >8 hours  | ED LOS                     | throughput       | predictive                    |
|   |   |   | total ED time                 | difference to nearest minute between recorded time of arrival in ED and recorded time of transfer to ward | ED LOS                     | throughput       | predictive                    |
| Richardson, <sup>145</sup><br>Australia | prospective cohort study, single centre   | to prospectively confirm increased average ward LOS in access block patients, in setting where access block is identified at time of admission; ED overcrowding defined according to presence of access block, situation where patients in ED are unable to gain timely access to appropriate in-patient beds | access block                  | total ED time >8 hours  | ED LOS                     | throughput       | discriminative or descriptive |
| Richardson, <sup>146</sup><br>Australia | retrospective cohort study, single centre | to use multivariate approach to identify causes of ED waiting time performance; to seek threshold for inadequate performance; ED overcrowding not defined   | number of presentations in ED | not described   | ED patient volumes overall | input            | predictive                    |
|   |   |   | access block                  | proportion of admissions spending >8 hours in ED  | access block               | output           | predictive                    |
|   |   |   | ED performance                | proportion of patients seen within certain time threshold   | ED administration          | throughput       | discriminative or descriptive |
|   |   |   | patient care time             | mean daily occupancy with patients being treated  | ED times                   | throughput       | predictive                    |
| Richardson, <sup>147</sup><br>Australia | prospective cohort study, single centre   | to prospectively assess total daily patient care time as predictor of waiting time performance in ED; ED overcrowding defined according to ED performance above threshold   | ED performance                | proportion of patients waiting less than triage time threshold each day                                   | ED administration          | throughput       | discriminative or descriptive |
|   |   |   | total daily patient care time | time from treatment start to departure from ED  | ED LOS                     | throughput       | predictive                    |

| Study                              | Design                                       | Objectives  | Measures   | Description                                       | Type of Measure            | Measure Category | Purpose                       |
|------------------------------------|--|---|--|---|----------------------------|------------------|-------------------------------|
| Rinderer, <sup>151</sup><br>US     | before-and-after study,<br>single centre     | to evaluate aspects of operations for quality improvement to reduce ED LOS for patients; to determine which factors could improve flow of patients through ED;<br>ED overcrowding not defined                                     | ED patient volumes                                   | not described                                     | ED patient volumes overall | input            | evaluative                    |
|                                    |  |   | LOS per visit  | not described                                     | ED times                   | throughput       | evaluative                    |
| Rogers, <sup>152</sup><br>UK       | before-and-after study,<br>single centre     | to assess effectiveness of “see and treat” system on waiting times for patients attending ED with minor injuries and illnesses;<br>ED overcrowding not defined  | percentage of patients discharged in 4 hours         | not described                                     | ED patient volumes         | output           | evaluative                    |
|                                    |  |   | percentage of patients admitted in 4 hours           | not described                                     | ED patient volumes         | output           | evaluative                    |
|                                    |  |   | percentage of patients triaged within 15 minutes     | percentage of patients assessed within 15 minutes | ED patient volumes         | throughput       | evaluative                    |
|                                    |  |   | percentage of patients seen within 1 hour of arrival | not described                                     | ED patient volumes         | throughput       | evaluative                    |
|                                    |  |   | percentage of patients discharged within 1 hour      | not described                                     | ED patient volumes         | throughput       | evaluative                    |
|                                    |  |   | time to see doctor or emergency nurse                | average wait to see doctor or nurse               | ED times                   | throughput       | evaluative                    |
|                                    |  |   | average total time in ED                             | not described                                     | ED times                   | throughput       | evaluative                    |
| Ross, <sup>153</sup><br>US         | retrospective cohort study,<br>single centre | to determine impact of 1 ED observation unit bed on in-patient bed availability;<br>ED overcrowding not defined   | ED LOS   | not described                                     | ED LOS                     | throughput       | discriminative or descriptive |
| Rotstein, <sup>154</sup><br>Israel | before-and-after study,<br>single centre     | to formulate dynamic statistical model to forecast need for allocating additional medical staff to improve efficacy of work in ED;<br>ED overcrowding not defined   | volume of patient admissions to ED                   | not described                                     | ED patient volumes overall | input            | predictive                    |
|                                    |  |   | LOS  | not described                                     | ED LOS                     | throughput       | evaluative                    |
| Ruoff, <sup>155</sup><br>US        | before-and-after study,<br>single centre     | to determine if physician-assisted triage to provide early evaluation and treatment of patients in waiting area will decrease LWBS or LAMA rates, and improve throughput and patient satisfaction;<br>ED overcrowding not defined | daily elopement rates                                | not described                                     | LWBS                       | throughput       | evaluative                    |
|                                    |  |   | LAMA rates   | not described                                     | LAMA                       | throughput       | evaluative                    |
|                                    |  |   | ED LOS   | not described                                     | ED LOS                     | throughput       | evaluative                    |

| Study                            | Design                                | Objectives  | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|----------------------------------|---------------------------------------|---|--|---|----------------------------|------------------|-------------------------------|
| Ryan, <sup>156</sup><br>US       | controlled trial, multicentre         | to investigate whether formal triage system reduced ED waiting times; ED overcrowding not defined   | waiting time to see doctor                         | not described   | ED times                   | throughput       | evaluative                    |
|                                  |                                       |   | waiting time to see nurse                          | not described   | ED times                   | throughput       | evaluative                    |
| Salazar, <sup>157</sup><br>Spain | before-and-after study, single centre | to analyze influence of multicomponent intervention at ED to alleviate crisis from annual Christmas ED overcrowding; ED overcrowding described as situation where patients have to stay in ED until beds become available | number of diversions to other hospitals            | not described   | ambulance diversion        | input            | evaluative                    |
|                                  |                                       |   | average daily attendance rate                      | not described   | ED patient volumes overall | input            | evaluative                    |
|                                  |                                       |   | mean total patients' LOS at ED                     | not described   | ED times                   | throughput       | evaluative                    |
|                                  |                                       |   | number of patients who LWBS by physician           | not described   | LWBS                       | throughput       | evaluative                    |
| Sanchez, <sup>158</sup><br>Spain | before-and-after study, single centre | to assess whether fast track area able to improve ED performance; ED overcrowding not defined   | waiting time to be seen                            | not described   | ED times                   | throughput       | evaluative                    |
|                                  |                                       |   | LOS  | not described   | ED LOS                     | throughput       | evaluative                    |
|                                  |                                       |   | rate of patients LWBS                              | not described   | LWBS                       | throughput       | discriminative or descriptive |
|                                  |                                       |   | number of visits                                   | not described   | ED patient volumes overall | input            | discriminative or descriptive |
|                                  |                                       |   | emergent patient rate                              | not described   | ED patient volumes overall | input            | discriminative or descriptive |
| Saxena, <sup>159</sup><br>US     | before-and-after study, single centre | to determine whether creation of dedicated stat laboratory in ED would improve turnaround times; ED overcrowding not defined  | turnaround time                                    | interval from time order for test is written until result is reviewed                 | ED times                   | throughput       | evaluative                    |
|                                  |                                       |   | within laboratory turnaround                       | time from accessioning to report release  | ED times                   | throughput       | evaluative                    |
|                                  |                                       |   | turnaround: collecting time (pre-analytic phase)   | time from written test order to specimen collection                                   | ED times                   | throughput       | evaluative                    |
|                                  |                                       |   | turnaround: sending time (pre-analytic phase)      | time from specimen collection to placement in pneumatic tube                          | ED times                   | throughput       | evaluative                    |
|                                  |                                       |   | turnaround: transporting time (pre-analytic phase) | time from transit in pneumatic tube to laboratory                                     | ED times                   | throughput       | evaluative                    |
|                                  |                                       |   | turnaround: accessioning time (pre-analytic phase) | time from arrival in laboratory to completion of accessioning as recorded in computer | ED times                   | throughput       | evaluative                    |

| Study                           | Design                                  | Objectives  | Measures   | Description  | Type of Measure            | Measure Category | Purpose                       |
|---------------------------------|---|---|--|--|----------------------------|------------------|-------------------------------|
|                                 |   |   | turnaround: processing (analytic phase)                  | time from accession time to specimen placement in analyzer   | ED times                   | throughput       | evaluative                    |
|                                 |   |   | turnaround: analyzing time (analytic phase)              | time from placement in analyzer to completion of test result   | ED times                   | throughput       | evaluative                    |
|                                 |   |   | turnaround: computing time (analytic phase)              | time from completion to entry and release in computer  | ED times                   | throughput       | evaluative                    |
|                                 |   |   | turnaround: acknowledging time (post-analytic phase)     | time from result release in computer to physician review of results on computer terminal   | ED times                   | throughput       | evaluative                    |
| Schaefer, <sup>160</sup><br>US  | before-and-after study, multicentre     | to investigate whether emergency medical technicians could decrease ED use by patients with non-urgent concerns who use 911 by appropriately identifying and triaging them to alternative care destination; ED overcrowding not defined     | number of ED visits                                      | not described  | ED patient volumes overall | input            | evaluative                    |
| Schneider, <sup>161</sup><br>US | retrospective cohort study, multicentre | to provide descriptive analysis of attempted solutions and outcomes for ED overcrowding; ED overcrowding not defined  | number of hours on diversion                             | number of hours where following conditions met: no available in-patient beds, no available ICU beds, 40% of beds in ED occupied by in-patients, delays in evaluation of waiting-room patients >4 hours | ambulance diversion        | input            | discriminative or descriptive |
|                                 |   |   | time from decision to admit to leave for in-patient room | not described  | access block               | output           | discriminative or descriptive |
| Schneider, <sup>162</sup><br>US | cross-sectional study, multicentre      | to assess feasibility of point prevalence study to assess degree of crowding in hospital ED; to measure degree of physical crowding and personnel shortage; physical ED crowding defined as having more patients in ED than treatment rooms | ambulance diversion                                      | time on diversion for study period   | ambulance diversion        | input            | discriminative or descriptive |
|                                 |   |   | time in boarding   | mean time of patients boarding episodes for study period   | access block               | output           | discriminative or descriptive |
|                                 |   |   | number of in-patients boarding in ED                     | mean of patients boarded in ED for study period  | access block               | output           | discriminative or descriptive |

| Study                            | Design                                   | Objectives  | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|----------------------------------|--|---|--|---|----------------------------|------------------|-------------------------------|
|                                  |  |   | number of patients per treatment space             | mean number of patients per treatment spaces for certain period   | ED patient volumes         | throughput       | discriminative or descriptive |
|                                  |  |   | nurse staffing ratio for ED critical beds          | patient to nurse ratio for ED critical beds   | ED administration          | throughput       | discriminative or descriptive |
|                                  |  |   | nurse staffing ratio for routine ED beds           | patient to nurse ratio for ED routine beds  | ED administration          | throughput       | discriminative or descriptive |
|                                  |  |   | physician staffing ratio                           | number of patients per physician at a time in ED  | ED administration          | throughput       | discriminative or descriptive |
|                                  |  |   | routine use of halls for treatment spaces          | frequency of use of halls or non-clinical space for patient care  | ED administration          | throughput       | discriminative or descriptive |
|                                  |  |   | LOS  | not described   | ED LOS                     | throughput       | discriminative or descriptive |
|                                  |  |   | number of patients waiting for on-call consultants | not described   | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                  |  |   | number of patients per treatment space             | number of patients placed in determined treatment space to receive patient  | ED patient volumes         | throughput       | discriminative or descriptive |
|                                  |  |   | LOS from treatment to release                      | time from treatment to ED discharge (minutes)   | ED times                   | throughput       | discriminative or descriptive |
|                                  |  |   | LOS (admission)                                    | time of admission in ED   | ED times                   | throughput       | discriminative or descriptive |
| Schreck, <sup>163</sup><br>US    | computer simulation model, single centre | to develop chaotic dynamics artificial neural network computer model that predicts patient LOS in ED queuing system; ED overcrowding not defined  | patient LOS in ED                                  | not described   | ED LOS                     | throughput       | discriminative or descriptive |
| Schull, <sup>164</sup><br>Canada | before-and-after study, multicentre      | to determine impact of systematic hospital restructuring on ED overcrowding; ED was considered overcrowded during periods of ambulance diversion; moderate: redirect consideration (defined as no ambulances accepted except those with critically ill patients); severe: critical care bypass (defined as no | total time for ED overcrowding                     | total time (in minutes) on ambulance diversion (per month): $(T/D \times 1,440 \times ED)$ where T=total minutes of overcrowding at all EDs in month, D=number of days in month, 1,440=number of minutes in day, and ED=number of open EDs in month | ambulance diversion        | input            | discriminative or descriptive |

| Study                            | Design                                   | Objectives  | Measures   | Description  | Type of Measure            | Measure Category | Purpose                       |
|----------------------------------|--|---|--|--|----------------------------|------------------|-------------------------------|
|                                  |  | ambulances accepted)  | total monthly volume of ED patients                                  | not described  | ED patient volumes overall | input            | predictive                    |
| Schull, <sup>31</sup><br>Canada  | prospective cohort study, single centre  | to determine relationship between physician, nurse, and patient factors on ED overcrowding; ED overcrowding defined as ambulance diversion  | ambulance diversion  | not described  | ambulance diversion        | input            | discriminative or descriptive |
|                                  |  |   | admitted patients held in ED   | number of admitted patients held in ED                                   | access block               | output           | predictive                    |
|                                  |  |   | assessment time  | time from registration to admission order                                | ED times                   | throughput       | predictive                    |
|                                  |  |   | holding time   | time from admission order to ED departure                                | access block               | output           | predictive                    |
| Schull, <sup>165</sup><br>Canada | prospective cohort study, single centre  | to determine relationship between physician, nurse, and patient factors on ED overcrowding; ED overcrowding defined as ambulance diversion  | ambulance diversion  | not described  | ambulance diversion        | input            | discriminative or descriptive |
|                                  |  |   | number of admitted patients held in ED                               | not described  | access block               | output           | predictive                    |
|                                  |  |   | holding time   | time from admission order to ED departure                                | access block               | output           | predictive                    |
|                                  |  |   | assessment time  | time from registration to admission                                      | ED times                   | throughput       | predictive                    |
| Schull, <sup>2</sup><br>Canada   | qualitative or Delphi study, Multicentre | to develop operational definition and parsimonious list of postulated determinants for urban ED overcrowding; several operational definitions of ED overcrowding discussed: ambulance diversion, ED workload measures, LOS of admitted patients in ED, patients with urgent triage codes who LWBS, average times before being seen by nurse or physician, and occupancy rate of ED stretchers; ambulance diversion considered to be appropriate proxy measure for ED overcrowding | total volume of ED visits  | not described  | ED patient volumes overall | input            | predictive                    |
|                                  |  |   | surges in number of newly arriving ambulance and ambulatory patients | not described  | ED patient volumes overall | input            | predictive                    |
|                                  |  |   | number of admitted patients held in ED                               | not described  | access block               | output           | predictive                    |
|                                  |  |   | ED consult response time   | not described  | ED times                   | throughput       | predictive                    |
|                                  |  |   | ED consult response times  | not described  | ED times                   | throughput       | predictive                    |
| Schull, <sup>166</sup><br>Canada | retrospective cohort study, multicentre  | to determine whether greater ambulance diversion associated with longer prehospital delays for  | overcrowding level   | percentage of time per month spent with redirect consideration status or | ambulance diversion        | input            | discriminative or descriptive |

| Study                            | Design                                  | Objectives  | Measures   | Description  | Type of Measure            | Measure Category | Purpose                       |
|----------------------------------|---|---|--|--|----------------------------|------------------|-------------------------------|
|                                  |   | patients with chest pain; ED overcrowding defined according to percentage of time per month spent on redirect consideration status or critical care bypass status, defined as redirect consideration (ED able to accept only critically ill or injured patients arriving by ambulance); all other ambulance patients should be referred by ambulance dispatcher, where possible and feasible, to emergency units in catchment area that have normal status; critical care bypass: emergency unit cannot accept critically ill or injured patients by ambulance, as patient care will be compromised; all ambulance patients redirected to ED in catchment area that have normal status or redirect consideration status |  | critical care bypass   |                            |                  |                               |
| Schull, <sup>167</sup><br>Canada | prospective cohort study, single centre | to determine relationship between physician, nurse, and patient factors on ED use of ambulance diversion; ED overcrowding defined according to criteria for episodes of ambulance diversion   | boarded patients                                 | number of admitted patients boarded in ED  | access block               | output           | predictive                    |
|                                  |   |   | volume of walk-in patients                       | not described  | ED patient volumes overall | input            | discriminative or descriptive |
|                                  |   |   | ambulance-delivered patients                     | not described  | ED patient volumes overall | input            | discriminative or descriptive |
|                                  |   |   | assessment time                                  | time from registration to admission order  | ED times                   | throughput       | discriminative or descriptive |
|                                  |   |   | boarding time                                    | time from admission order to ED departure  | access block               | output           | discriminative or descriptive |
|                                  |   |   | total duration in minutes of ambulance diversion | total minutes on redirect consideration or critical care bypass during 8-hour interval | ambulance diversion        | input            | discriminative or descriptive |

| Study                            | Design                                    | Objectives   | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|----------------------------------|---|--|--|---|----------------------------|------------------|-------------------------------|
|                                  |   |  | total patient volume   | sum of walk-in and ambulance-delivered patients   | ED patient volumes overall | input            | discriminative or descriptive |
| Schull, <sup>168</sup><br>Canada | retrospective cohort study, multicentre   | to determine effect of simultaneous ambulance diversion at multiple EDs on transport delays for patient with chest pain; ED considered to be overcrowded during periods of ambulance diversion; moderate: redirect consideration (no ambulances accepted except those with critically ill patients); severe: critical care bypass (no ambulances accepted) | gridlock time  | daily duration of episodes where all ED in city quadrant simultaneously diverting ambulances          | ambulance diversion        | input            | predictive                    |
| Schull, <sup>169</sup><br>Canada | retrospective cohort study, single centre | to study effect of one input factor (community influenza outbreak) on ED crowding; ED crowding present when throughput or output in ED cannot keep pace with inputs  | weekly duration of critical care bypass                          | duration of highest level of ambulance diversion during which all ambulances diverted to other ED     | ambulance diversion        | input            | discriminative or descriptive |
| Schull, <sup>170</sup><br>Canada | retrospective cohort study, multicentre   | to examine mechanism behind association between influenza season and ED crowding; ED overcrowding not defined  | total number of ED visits per week                               | not described   | ED patient volumes overall | input            | discriminative or descriptive |
|                                  |   |  | percentage of ED visits by diagnosis                             | number of patients per week (by diagnostic group) divided by total number of all ED patients for week | ED patient volumes overall | input            | discriminative or descriptive |
| Schull, <sup>171</sup><br>Canada | retrospective cohort study, multicentre   | to estimate effect of ED overcrowding on door-to-needle time for patients given intravenous thrombolysis for suspected acute myocardial infarction; ED overcrowding defined as situation where ED was diverting ambulances   | network crowding   | percentage of EDs that were diverting ambulances on patient registration                              | ambulance diversion        | input            | predictive                    |
|                                  |   |  | proportion of patients with “delayed” door-to-needle time        | proportion of patients with door-to-needle time between 30 and 60 minutes                             | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                  |   |  | proportion of patients with “major delay” in door-to-needle time | proportion of patients with door-to-needle time >60 minutes   | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                  |   |  | door-to-needle time  | time from ED registration to drug administration  | ED times                   | throughput       | discriminative or descriptive |

| Study                             | Design                                     | Objectives  | Measures   | Description                                     | Type of Measure            | Measure Category | Purpose                       |
|-----------------------------------|--|---|--|---|----------------------------|------------------|-------------------------------|
| Sedlak, <sup>172</sup><br>US      | before-and-after study,<br>single centre   | to evaluate effects of multi-component intervention to overcome hurdles associated with ED overcrowding;<br>ED overcrowding not defined   | overall ED LOS   | not described                                   | ED times                   | throughput       | evaluative                    |
|                                   |  |   | time from arrival to time to be seen by doctor                       | not described                                   | ED times                   | throughput       | evaluative                    |
|                                   |  |   | turnaround times: time from order input to examination               | not described                                   | ED times                   | throughput       | evaluative                    |
|                                   |  |   | turnaround times: time from order input to interpreted results in ED | not described                                   | ED times                   | throughput       | evaluative                    |
|                                   |  |   | time spent by ED patients waiting for radiological examinations      | not described                                   | ED times                   | throughput       | evaluative                    |
|                                   |  |   | number of patients who LWBS  | not described                                   | LWBS                       | throughput       | evaluative                    |
| Shih, <sup>173</sup><br>Taiwan    | prospective cohort study,<br>single centre | to quantify extent of ED overcrowding;<br>ED overcrowding present when ED is filled with patients needing admission, but who cannot leave ED because of unavailability of in-patient beds | number of patients with prolonged LOS                                | proportion of patients with LOS >72 hours in ED | ED patient volumes         | throughput       | discriminative or descriptive |
| Shrimpling, <sup>174</sup><br>UK  | before-and-after study,<br>single centre   | to assess effect of implementing senior triage team on waiting times for all ED patients;<br>ED overcrowding not defined  | total time in ED   | not described                                   | ED LOS                     | throughput       | evaluative                    |
|                                   |  |   | total time spent with ED practitioners                               | not described                                   | ED times                   | throughput       | evaluative                    |
|                                   |  |   | waiting times throughout ED  | not described                                   | ED times                   | throughput       | evaluative                    |
| Siddharthan, <sup>175</sup><br>US | prospective cohort study,<br>single centre | to investigate effect of congestion and resulting increases in service times for emergency provision from improper use of ED;<br>ED overcrowding not defined                              | arrival rate of ED care patients                                     | number of patients arriving at ED per hour      | ED patient volumes overall | input            | discriminative or descriptive |
|                                   |  |   | inter-arrival time   | time between subsequent arrivals                | ED times                   | input            | discriminative or descriptive |
|                                   |  |   | percentage of patients requiring blood tests and X-rays              | not described                                   | ED patient volumes         | throughput       | discriminative or descriptive |
|                                   |  |   | percentage of patients requiring blood tests only                    | not described                                   | ED patient volumes         | throughput       | discriminative or descriptive |
|                                   |  |   | percentage of patients requiring X-rays only                         | not described                                   | ED patient volumes         | throughput       | discriminative or descriptive |
|                                   |  |   | average service time   | average time elapsing between registering in ED | ED times                   | throughput       | discriminative or descriptive |

| Study                       | Design                                    | Objectives  | Measures                                       | Description  | Type of Measure     | Measure Category | Purpose                       |
|-----------------------------|---|---|--|--|---------------------|------------------|-------------------------------|
|                             |   |   |  | and discharge  |                     |                  |                               |
|                             |   |   | average waiting time for ED admission          | not described  | ED times            | throughput       | discriminative or descriptive |
|                             |   |   | patient evaluation time                        | total time spent by physicians and nurses in bedside care and in consultation with specialists   | ED times            | throughput       | discriminative or descriptive |
|                             |   |   | time for tests (blood)                         | average times for ordering, administration, and return of blood test results   | ED times            | throughput       | discriminative or descriptive |
|                             |   |   | time for tests (X-ray)                         | average times for ordering, administration, and return of X-ray results  | ED times            | throughput       | discriminative or descriptive |
|                             |   |   | total time for tests (weighted by percentage)  | not described  | ED times            | throughput       | discriminative or descriptive |
|                             |   |   | patient care time (weighted)                   | sum of patient evaluation time and weighted total times (weighted by percentage of patients in each category) for tests                  | ED times            | throughput       | discriminative or descriptive |
|                             |   |   | average service rate                           | 1 divided by total care time   | ED times            | throughput       | discriminative or descriptive |
|                             |   |   | total waiting time                             | average service time – patient care time (weighted)  | ED times            | throughput       | discriminative or descriptive |
|                             |   |   | waiting time in ED                             | total waiting time – average waiting time for ED admission   | ED times            | throughput       | discriminative or descriptive |
| Simon, <sup>176</sup><br>US | retrospective cohort study, single centre | to examine value of fast track system for triage accuracy and turnaround times in ED; ED overcrowding not defined   | turnaround time                                | total time from triage to discharge  | ED times            | throughput       | evaluative                    |
| Solberg, <sup>4</sup><br>US | qualitative or Delphi study, multicentre  | to identify measures of ED overcrowding and hospital workflow that would be of value in understanding, monitoring, and managing overcrowding; ED overcrowding not defined | ambulance diversion episodes                   | number and duration of all diversion episodes at EDs in Emergency Medical Service (EMS) system within defined period (week, month, year) | ambulance diversion | input            | discriminative or descriptive |
|                             |   |   | ambulance diversion requests denied and forced | number of diversion requests denied or forced openings   | ambulance diversion | input            | discriminative or descriptive |

| Study | Design | Objectives | Measures   | Description   | Type of Measure            | Measure Category | Purpose                       |
|-------|--------|------------|--|---|----------------------------|------------------|-------------------------------|
|       |        |            | openings   | within defined period (week, month, year)   |                            |                  |                               |
|       |        |            | diverted ambulance patient description                       | chief complaints and final destination of diverted EMS patients within defined period (week, month, year)                       | ambulance diversion        | input            | discriminative or descriptive |
|       |        |            | percentage of open appointments                              | percentage of open appointments at beginning of day in ambulatory care clinics that serve ED's patient population               | ED administration          | input            | discriminative or descriptive |
|       |        |            | ED patient volume, standardized for bed hours                | number of new patients registered within defined period (hour, shift, day) ÷ number of ED bed-hours within this period          | ED patient volumes overall | input            | discriminative or descriptive |
|       |        |            | ED patient volume, standardized for annual average           | number of new patients registered within defined period ÷ annual mean number of new patients registered within this period      | ED patient volumes overall | input            | discriminative or descriptive |
|       |        |            | ED ambulance patient volume, standardized for bed-hours      | number of new ambulance patients registered within defined period ÷ number of ED bed-hours within this period                   | ED patient volumes overall | input            | discriminative or descriptive |
|       |        |            | ED ambulance patient volume, standardized for annual average | number of new ambulance patients within defined period ÷ annual average of new ambulance patients registered within this period | ED patient volumes overall | input            | discriminative or descriptive |
|       |        |            | patient complexity as percentage of ambulance patients       | percentage of patients registering at ED in defined period (shift, day, week, month) who arrived by ambulance                   | ED patient volumes overall | input            | discriminative or descriptive |
|       |        |            | average EMS waiting time                                     | total time at hospital for ambulances delivering patients to ED during defined period (shift, day,                              | ambulance diversion        | input            | discriminative or descriptive |

| Study | Design | Objectives | Measures                             | Description  | Type of Measure   | Measure Category | Purpose                       |
|-------|--------|------------|--------------------------------------|--|-------------------|------------------|-------------------------------|
|       |        |            |                                      | week, month) ÷ number of ambulance deliveries within that period   |                   |                  |                               |
|       |        |            | boarding burden                      | mean number of ED patients waiting for inpatient bed within defined period ÷ number of staffed ED treatment areas  | access block      | output           | discriminative or descriptive |
|       |        |            | ED admission transfer rate           | number of patients transferred from ED to another facility who would normally have been admitted within defined period ÷ number of ED admissions within this period                          | ED administration | output           | discriminative or descriptive |
|       |        |            | observation unit census              | mean number of available ED observation beds at defined time ÷ number of staffed ED observation beds   | ED administration | output           | discriminative or descriptive |
|       |        |            | ED volume or hospital capacity ratio | number of new ED patients within defined period (shift/day) ÷ number of available hospital beds at beginning of analysis period overall and by bed type                                      | ED administration | output           | discriminative or descriptive |
|       |        |            | ED boarding time                     | mean time from in-patient bed request to physical departure of patients from ED overall and by bed type within defined period (shift, day, week) (bed type=ICU, telemetry, psychiatry, ward) | ED times          | output           | discriminative or descriptive |
|       |        |            | ED boarding time components          | mean time from in-patient bed request to physical departure of patients from ED by bed type by component (bed assignment, bed cleaning, transfer arrival) within defined period              | ED times          | output           | discriminative or descriptive |

| Study | Design | Objectives | Measures  | Description  | Type of Measure            | Measure Category | Purpose                       |
|-------|--------|------------|---|--|----------------------------|------------------|-------------------------------|
|       |        |            | summary workload, standardized for ED bed-hours                 | summary of (patients treated $\times$ acuity) in defined period (shift, day, week) $\div$ number of ED bed hours within this period                | ED administration          | throughput       | discriminative or descriptive |
|       |        |            | summary workload, standardized for registered nurse staff-hours | summary of (patients treated $\times$ acuity) in defined period (shift, day, week) $\div$ total ED staff registered nurse-hours within this period | ED administration          | throughput       | discriminative or descriptive |
|       |        |            | summary workload, standardized for physician staff-hours        | summary of (patients treated $\times$ acuity) in defined period (shift, day, week) $\div$ total ED staff physician-hours within this period        | ED administration          | throughput       | discriminative or descriptive |
|       |        |            | patient disposition to physician staffing ratio                 | number of patients admitted or discharged per staff physician during defined period (shift, day, week)   | ED administration          | throughput       | discriminative or descriptive |
|       |        |            | ED occupancy rate   | total number of ED patients registered at defined time $\div$ number of staffed treatment areas at that time                                       | ED patient volumes overall | throughput       | discriminative or descriptive |
|       |        |            | ED occupancy  | total number of patients present in ED at defined time $\div$ number of staffed treatment areas at that time                                       | ED patient volumes overall | throughput       | discriminative or descriptive |
|       |        |            | ED throughput time  | average time between patient sign-in and departure (separately for admitted versus discharged patients) within defined period (day, week, month)   | ED times                   | throughput       | discriminative or descriptive |
|       |        |            | ED bed placement time   | mean interval between patient sign-in and placement in treatment area within defined period (shift, day, week, month)                              | ED times                   | throughput       | discriminative or descriptive |
|       |        |            | ED ancillary service turnaround time                            | average time between physician order and result  | ED times                   | throughput       | discriminative or descriptive |

| Study                          | Design                                | Objectives   | Measures  | Description  | Type of Measure            | Measure Category | Purpose                       |
|--------------------------------|---------------------------------------|--|---|--|----------------------------|------------------|-------------------------------|
|                                |                                       |  |   | report (separately for each service area) within defined period (shift, day, week, month)  |                            |                  |                               |
|                                |                                       |  | percentage of patients who leave without treatment complete | number of registered patients who leave ED without treatment complete ÷ total number of patients who register during this period | LWBS                       | throughput       | discriminative or descriptive |
|                                |                                       |  | leave without treatment complete severity                   | average severity of patients who leave ED without treatment complete within defined period (shift, day, week)                    | LWBS                       | throughput       | discriminative or descriptive |
| Spaite, <sup>177</sup><br>US   | before-and-after study, single centre | to describe application of process-improvement team approach to evaluate and redesign ED patient flow; ED overcrowding not defined   | ED patient volume   | not described  | ED patient volumes overall | input            | discriminative or descriptive |
|                                |                                       |  | median patient waiting room time interval                   | time from triage to patient room   | ED times                   | throughput       | evaluative                    |
|                                |                                       |  | ED throughput times   | not described  | ED times                   | throughput       | evaluative                    |
|                                |                                       |  | number of patients who LWBS                                 | not described  | LWBS                       | throughput       | evaluative                    |
| Subash, <sup>178</sup><br>UK   | controlled trial, single centre       | to evaluate whether 3 hours of combined doctor and nurse triage would lead to earlier medical assessment, and treatment in ED; to determine whether this benefit would carry on for rest of day when normal triage is resumed; ED overcrowding not defined | number of patients treated and discharged within 20 minutes | not described  | ED patient volumes         | throughput       | evaluative                    |
|                                |                                       |  | time to triage  | not described  | ED times                   | throughput       | evaluative                    |
|                                |                                       |  | time to see doctor  | not described  | ED times                   | throughput       | evaluative                    |
|                                |                                       |  | time to radiology   | not described  | ED times                   | throughput       | evaluative                    |
|                                |                                       |  | time to discharge   | not described  | ED times                   | throughput       | evaluative                    |
|                                |                                       |  | time to nurse discharge                                     | not described  | ED times                   | throughput       | evaluative                    |
| Swafford, <sup>179</sup><br>US | cross-sectional study, multicentre    | to identify effects of ED overcrowding on emergency medicine (EM) resident education as perceived by chief residents in EM; ED overcrowding definitions provided by survey respondents according to number of patients                                     | ED patient census   | not described  | ED patient volumes overall | input            | discriminative or descriptive |
|                                |                                       |  | all ED beds occupied >6 hours per day                       | not described  | ED administration          | throughput       | discriminative or descriptive |
|                                |                                       |  | patients remain in hallways for >6 hours per day            | not described  | ED administration          | throughput       | discriminative or descriptive |

| Study                                 | Design                                | Objectives   | Measures  | Description  | Type of Measure            | Measure Category | Purpose                       |
|---------------------------------------|---------------------------------------|--|---|--|----------------------------|------------------|-------------------------------|
|                                       |                                       | who wait >60 minutes to see physician; when all ED beds filled for >6 hours per day; when patients are placed in hallways for >6 hours per day; when physicians feel rushed for >6 hours per day; when waiting rooms are filled >6 hours per day   | waiting rooms filled >6 hours per day                       | not described  | ED administration          | throughput       | discriminative or descriptive |
|                                       |                                       |  | frequency of overcrowding                                   | ED residents' perception of number of times per week when any definition of overcrowding met | ED administration          | system           | discriminative or descriptive |
|                                       |                                       |  | proportion of patients waiting >60 minutes to see physician | not described  | ED patient waiting volumes | throughput       | discriminative or descriptive |
|                                       |                                       |  | ED physicians feel rushed >6 hours per day                  | not described  | ED administration          | throughput       | discriminative or descriptive |
| Takakuwa, <sup>180</sup><br>US        | before-and-after study, single centre | to evaluate effect of bedside registration on patient encounter times; ED overcrowding not defined   | time from triage to room                                    | not described  | ED times                   | throughput       | evaluative                    |
|                                       |                                       |  | time from room to disposition                               | not described  | ED times                   | throughput       | evaluative                    |
| Terris, <sup>181</sup><br>UK          | controlled trial, single centre       | to assess whether initial patient consult by senior clinicians reduces numbers of patients waiting to be seen at ED; ED overcrowding not defined   | number of patients waiting to be seen for triage            | not described  | ED patient waiting volumes | throughput       | evaluative                    |
|                                       |                                       |  | number of patients waiting to be seen for minors            | not described  | ED patient waiting volumes | throughput       | evaluative                    |
|                                       |                                       |  | number of patients waiting to be seen for majors            | not described  | ED patient waiting volumes | throughput       | evaluative                    |
|                                       |                                       |  | number of patients waiting to be seen (overall)             | not described  | ED patient waiting volumes | throughput       | evaluative                    |
|                                       |                                       |  | number of patients who had to wait >4 hours to see doctor   | not described  | ED patient waiting volumes | throughput       | evaluative                    |
| The Lewin Group, <sup>182</sup><br>US | cross-sectional study, multicentre    | to gather US representative data on perceptions of ED volume and capacity, diversion rates, reasons for diversion, impact on service levels, volume trends, and volume of uninsured patients visiting ED; ED overcrowding described as a situation where ED hospitals perceive they are "at" or "over" | ED diversion episodes                                       | number of times when ED can no longer accept all or specific types of patients by ambulance  | ambulance diversion        | input            | discriminative or descriptive |
|                                       |                                       |  | time on diversion   | mean days per month in which period of ED diversion occurred                                 | ambulance diversion        | input            | discriminative or descriptive |
|                                       |                                       |  | ED visit volume   | not described  | ED patient volumes         | input            | discriminative or descriptive |

| Study  | Design                                | Objectives   | Measures  | Description   | Type of Measure     | Measure Category | Purpose                       |
|--|---------------------------------------|--|---|---|---------------------|------------------|-------------------------------|
|  |                                       | operating capacity   |   |   | overall             |                  |                               |
|  |                                       |  | average time waiting for transfer from ED to acute or critical care bed | not described   | access block        | output           | discriminative or descriptive |
|  |                                       |  | average time waiting for transfer from ED to bed                        | not described   | access block        | output           | discriminative or descriptive |
|  |                                       |  | waiting time for treatment  | average waiting time for treatment by physician or other provider   | ED times            | throughput       | discriminative or descriptive |
|  |                                       |  | average LOS in ED treatment area  | not described   | ED times            | throughput       | discriminative or descriptive |
| Toncich, <sup>183</sup><br>Australia               | before-and-after study, single centre | to determine usefulness of Health Care Improvement interventions to improve process times in ED; ED overcrowding not defined   | LOS for admitted patients   | not described   | ED times            | throughput       | evaluative                    |
|  |                                       |  | LOS for discharged patients   | not described   | ED times            | throughput       | evaluative                    |
|  |                                       |  | LOS for total ED patients   | not described   | ED times            | throughput       | evaluative                    |
| US General Accounting Office, <sup>184</sup><br>US | cross-sectional study, multicentre    | to evaluate to what extent hospitals in US metropolitan areas are experiencing crowding in ED; to evaluate what factors contribute to ED crowding; to describe actions that hospitals and communities have taken to address crowding; 3 indicators of ED crowding chosen: diversion, boarding, and leave before medical evaluation | number of hours on diversion  | total of hours in which hospitals requested that ambulances bypass EDs and transport patients who would have been otherwise taken to those EDs to other medical facilities                                      | ambulance diversion | input            | discriminative or descriptive |
|  |                                       |  | average number of hours of patients boarding                            | average number of hours that patients waited to leave ED after decision to admit or transfer made   | access block        | output           | discriminative or descriptive |
|  |                                       |  | percentage of patients boarded in ED for $\geq 2$ hours                 | percentage of patients who were boarded for $\geq 2$ hours; boarding defined as situation where decision to admit or transfer emergency patient has been made, and patient waits to leave ED for certain period | access block        | output           | discriminative or descriptive |
|  |                                       |  | proportion of patients who left before medical evaluation               | number of patients who left after triage but before medical evaluation as percentage of ED visits   | LWBS                | throughput       | discriminative or descriptive |

| Study                             | Design                                    | Objectives  | Measures                                  | Description   | Type of Measure            | Measure Category | Purpose                       |
|-----------------------------------|---|---|---|---|----------------------------|------------------|-------------------------------|
| Uy, <sup>185</sup><br>Canada      | prospective cohort study, single centre   | to evaluate patient flow patterns and system bottlenecks in ED from patient arrival to initial physician assessment; ED overcrowding not defined  | waiting time for triage                   | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                   |   |   | waiting time for physician assessment     | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                   |   |   | waiting time to enter examination cubicle | not described   | ED times                   | throughput       | discriminative or descriptive |
| Vertesi, <sup>186</sup><br>Canada | retrospective cohort study, single centre | to quantify resource implications, in terms of stretcher use and waiting times, related to non-urgent patient visits; to estimate potential impact on ED flow of redirecting these patients to alternative primary care settings; ED overcrowding not defined | total of ED visits                        | not described   | ED patient volumes overall | input            | discriminative or descriptive |
|                                   |   |   | time for available stretchers             | average time to placement for patients requiring stretcher  | ED times                   | output           | discriminative or descriptive |
| Vilke, <sup>187</sup><br>US       | before-and-after study, multicentre       | to evaluate effect of staying off ED diversion; ED overcrowding not defined   | diversion hours                           | hours of ED diversion at facilities   | ambulance diversion        | input            | evaluative                    |
|                                   |   |   | number of diverted patients               | number of patients diverted from facilities   | ambulance diversion        | input            | evaluative                    |
|                                   |   |   | ED census                                 | not described   | ED patient volumes overall | input            | evaluative                    |
|                                   |   |   | ambulance runs                            | number of patients arriving by ambulance  | ED patient volumes overall | input            | evaluative                    |
| Vilke, <sup>188</sup><br>US       | before-and-after study, multicentre       | to evaluate community intervention to reduce ambulance diversion from ED; ED overcrowding not defined   | time on diversion                         | number of hours on diversion  | ambulance diversion        | input            | evaluative                    |
|                                   |   |   | number of diverted patients               | total number of patients who requested particular ED but were taken to another ED because of diversion status | ambulance diversion        | input            | evaluative                    |
|                                   |   |   | bypass hours                              | number of hours on diversion  | ambulance diversion        | input            | evaluative                    |
|                                   |   |   | ED visits                                 | number of ED visits   | ED patient volumes overall | input            | evaluative                    |
| Waldrop, <sup>189</sup><br>US     | prospective cohort study, single centre   | to examine effectiveness of established ED triage system in predicting admissions and determining waiting time to   | mean waiting time to examination          | not described   | ED times                   | throughput       | discriminative or descriptive |
|                                   |   |   | time to admission or discharge            | not described   | ED times                   | throughput       | discriminative or descriptive |

| Study                        | Design                                  | Objectives  | Measures   | Description  | Type of Measure            | Measure Category | Purpose                       |
|------------------------------|---|---|--|--|----------------------------|------------------|-------------------------------|
|                              |   | examination;<br>ED overcrowding not defined   | number of patients triaged who deserted before examination | not described  | LWBS                       | throughput       | discriminative or descriptive |
| Warden, <sup>190</sup><br>US | retrospective cohort study, multicentre | to evaluate amount of ambulance diversion in EMS system; to investigate potential predictive factors of ambulance diversion; ED overcrowding not defined  | ED census volume   | not described  | ED patient volumes overall | input            | evaluative                    |
|                              |   |   | total burden of ambulance diversion status                 | sum of times in total ambulance divert and total critical care divert time             | ambulance diversion        | input            | discriminative or descriptive |
|                              |   |   | total ambulance divert time                                | total cumulative time on ambulance diversion in category of total ambulance divert     | ambulance diversion        | input            | discriminative or descriptive |
|                              |   |   | total critical care divert time                            | total cumulative time on ambulance diversion in category of total critical care divert | ambulance diversion        | input            | discriminative or descriptive |
| Weiss, <sup>30</sup><br>US   | cross-sectional study, single centre    | to develop and pilot sampling form that accurately reflects concept of ED overcrowding; ED overcrowding defined as situation where all available beds in ED are full; patients placed in ED hallways because there are no in-patient beds available; number of hours ED is closed because of saturation or on diversion to ambulance traffic; waiting room is full; ED physicians feel rushed; waits to see physician are >1 hour | present diversion status                                   | if ED is on diversion  | ambulance diversion        | input            | predictive                    |
|                              |   |   | number of patients in waiting room                         | not described  | ED patient waiting volumes | input            | predictive                    |
|                              |   |   | number of patients at triage                               | not described  | ED patient volumes         | input            | predictive                    |
|                              |   |   | number of patients at registration                         | not described  | ED patient volumes         | input            | predictive                    |
|                              |   |   | number of patients awaiting beds                           | not described  | access block               | output           | predictive                    |
|                              |   |   | number of patients awaiting transfer out                   | not described  | access block               | output           | predictive                    |
|                              |   |   | number of patients awaiting consults                       | not described  | ED patient waiting volumes | output           | predictive                    |
|                              |   |   | number of full rooms                                       | not described  | ED administration          | throughput       | predictive                    |
|                              |   |   | longest time in ED since admission                         | not described  | access block               | output           | predictive                    |
|                              |   |   | longest time in ED for admitted patient since              | not described  | ED LOS                     | throughput       | predictive                    |

| Study | Design | Objectives | Measures  | Description  | Type of Measure            | Measure Category | Purpose                       |
|-------|--------|------------|---|--|----------------------------|------------------|-------------------------------|
|       |        |            | registration  |  |                            |                  |                               |
|       |        |            | number of hallway patients                                      | not described  | ED patient volumes         | throughput       | predictive                    |
|       |        |            | number of patients on ventilators                               | not described  | ED patient volumes         | throughput       | predictive                    |
|       |        |            | total patients registered                                       | not described  | ED patient volumes overall | throughput       | predictive                    |
|       |        |            | number of patients awaiting computer tomographic scans          | not described  | ED patient waiting volumes | throughput       | predictive                    |
|       |        |            | number of patients awaiting X-rays                              | not described  | ED patient waiting volumes | throughput       | predictive                    |
|       |        |            | longest time in ED for ED patient                               | not described  | ED times                   | throughput       | predictive                    |
|       |        |            | wait from registration until called from waiting room           | not described  | ED times                   | throughput       | predictive                    |
|       |        |            | wait from triage time until called from waiting room            | not described  | ED times                   | throughput       | predictive                    |
|       |        |            | time from X-ray order until call for X-ray                      | not described  | ED times                   | throughput       | predictive                    |
|       |        |            | laboratory turnaround time for blood tests                      | not described  | ED times                   | throughput       | predictive                    |
|       |        |            | charge nurse opinion on ED overcrowding                         | 5-point Likert-like scale to indicate nurses' point of view on degree of overcrowding      | ED administration          | throughput       | discriminative or descriptive |
|       |        |            | ED physician opinion on ED overcrowding                         | 5-point Likert-like scale to indicate physicians' point of view on degree of overcrowding  | ED administration          | throughput       | discriminative or descriptive |
|       |        |            | ED physician feeling of being rushed                            | 5-point Likert-like scale to indicate physicians' point of view on feeling of being rushed | ED administration          | throughput       | discriminative or descriptive |
|       |        |            | combined variable on ED overcrowding based on staff perceptions | average responses of nurses and physicians' opinions of ED overcrowding and                | ED administration          | throughput       | discriminative or descriptive |

| Study                       | Design                                    | Objectives   | Measures   | Description  | Type of Measure            | Measure Category | Purpose                       |
|-----------------------------|---|--|--|--|----------------------------|------------------|-------------------------------|
|                             |   |  |  | physicians' feeling of being rushed; cut off of 3.0 to indicate overcrowding |                            |                  |                               |
| Weiss, <sup>191</sup><br>US | retrospective cohort study, single centre | to evaluate whether LWBS can be predicted using validated scale for academic ED overcrowding, number of ambulances that arrive, and number of patients signing in at registration;<br>ED overcrowding defined according to National ED Overcrowding Study (NEDOCS) score | number of patients signed in who eventually LWBS                     | not described  | LWBS                       | throughput       | discriminative or descriptive |
|                             |   |  | NEDOCS score   | measure of ED overcrowding   | ED administration          | system           | predictive                    |
|                             |   |  | number of patients registered  | not described  | ED patient volumes overall | input            | predictive                    |
|                             |   |  | number of ambulances that arrived                                    | not described  | ED patient volumes overall | input            | predictive                    |
| Weiss, <sup>23</sup><br>US  | cross-sectional study, multicentre        | to develop screening tool to determine degree of ED overcrowding in hospital ED; to validate model to predict ED overcrowding; to quantitatively describe ED staff's sense of overcrowding;<br>ED overcrowding not defined   | 24 hours diversion   | how many hours out of last 24 ED has been on diversion                       | ambulance diversion        | input            | predictive                    |
|                             |   |  | time on diversion  | percentage of time on diversion at ED  | ambulance diversion        | input            | predictive                    |
|                             |   |  | time on community diversion plan                                     | percentage of time on community diversion plan                               | ambulance diversion        | input            | predictive                    |
|                             |   |  | ED numbers in waiting room   | number of patients in waiting room divided by number of ED beds              | ED patient waiting volumes | input            | predictive                    |
|                             |   |  | ED numbers at triage   | number of patients waiting to be seen at triage                              | ED patient waiting volumes | input            | predictive                    |
|                             |   |  | ED numbers at registration   | number of patients waiting to be seen at registration                        | ED patient waiting volumes | input            | predictive                    |
|                             |   |  | number of patients awaiting admission (flow of patients out of ED)   | number of patients awaiting admission divided by number of hospital beds     | access block               | output           | predictive                    |
|                             |   |  | number of patients waiting transfer out (flow of patients out of ED) | number of patients waiting to be transferred to another facility             | access block               | output           | predictive                    |
|                             |   |  | number of patients awaiting consults (flow of patients out of ED)    | patients who had been managed by ED and waiting consults                     | ED patient waiting volumes | output           | predictive                    |
|                             |   |  | bed time   | longest time in ED for admitted patient since                                | access block               | output           | predictive                    |

| Study | Design | Objectives | Measures   | Description   | Type of Measure            | Measure Category | Purpose    |
|-------|--------|------------|--|---|----------------------------|------------------|------------|
|       |        |            |  | admission   |                            |                  |            |
|       |        |            | number of full ED rooms  | not described   | ED administration          | throughput       | predictive |
|       |        |            | number of ED hallway patients  | not described   | ED patient volumes         | throughput       | predictive |
|       |        |            | number of doubled-up patients  | number of extra patients filling beds placed in rooms that are beyond room's normal capacity                    | ED patient volumes         | throughput       | predictive |
|       |        |            | total ED patients  | number of patients in ED beds: sum of full rooms, hallway, and doubled-up patients divided by number of ED beds | ED patient volumes overall | throughput       | predictive |
|       |        |            | number of patients awaiting computer tomographic scans (number of patients waiting for more tests) | not described   | ED patient waiting volumes | throughput       | predictive |
|       |        |            | number of patients awaiting radiographs (number of patients waiting for more tests)                | not described   | ED patient waiting volumes | throughput       | predictive |
|       |        |            | number of patients on ventilators  | number of intubated severely ill patients who were admitted but were not yet moved to intensive care beds       | ED patient volumes         | throughput       | predictive |
|       |        |            | time awaiting laboratory tests   | time from laboratory test order until completed   | ED times                   | throughput       | predictive |
|       |        |            | ED time  | longest time in ED for ED patient since registration  | ED times                   | throughput       | predictive |
|       |        |            | admit time   | longest time in ED for admitted patient since registration  | ED times                   | throughput       | predictive |
|       |        |            | registration time  | time from registration until called from waiting room   | ED times                   | throughput       | predictive |
|       |        |            | triage time  | time from triage until called from waiting room   | ED times                   | throughput       | predictive |
|       |        |            | time to complete tests   | time when last laboratory test or radiograph was being  | ED times                   | throughput       | predictive |

| Study                          | Design                                    | Objectives   | Measures  | Description  | Type of Measure   | Measure Category | Purpose                       |
|--------------------------------|---|--|---|--|-------------------|------------------|-------------------------------|
|                                |   |  |   | done related to time at which it was ordered   |                   |                  |                               |
|                                |   |  | time awaiting X-ray   | time from X-ray order until called for X-ray   | ED times          | throughput       | predictive                    |
|                                |   |  | ED physician opinion on overcrowding  | 6-point Likert-like scale: 1=not busy, 6=dangerously overcrowded, overcrowding: 3 to 4 cut-off | ED administration | throughput       | discriminative or descriptive |
|                                |   |  | ED physician feeling of being rushed  | 6-point Likert-like scale: 1=not being rushed, 6=dangerously rushed                            | ED administration | throughput       | discriminative or descriptive |
|                                |   |  | charge nurse opinion on ED overcrowding   | 6-point Likert-like scale: 1=not busy, 6=dangerously overcrowded; overcrowding: 3 to 4 cut-off | ED administration | throughput       | discriminative or descriptive |
|                                |   |  | composite score on ED overcrowding based on staff perceptions                   | NEDOCS score (0=not busy, 200=dangerously overcrowded); overcrowding: 100 points               | ED administration | throughput       | discriminative or descriptive |
| Winn, <sup>192</sup><br>US     | retrospective cohort study, single centre | to determine if nurse ordering of diagnostic tests from triage protocols would decrease patient time in ED; ED overcrowding not defined  | ED LOS  | unit of time as measured from time of patient triage to time of patient discharge from ED      | ED LOS            | throughput       | evaluative                    |
| Yoon, <sup>193</sup><br>Canada | retrospective cohort study, single centre | to identify and quantify principal ED patient care time intervals; to measure impact of important service processes on ED LOS for patients in different triage levels; ED overcrowding not defined | time from disposition decision to actual departure from ED                      | not described  | ED times          | output           | discriminative or descriptive |
|                                |   |  | time from ED entry (registration) to triage nurse assessment                    | not described  | ED times          | throughput       | discriminative or descriptive |
|                                |   |  | time from triage assessment to nursing assessment                               | not described  | ED times          | throughput       | discriminative or descriptive |
|                                |   |  | time from nursing assessment to physician assessment                            | not described  | ED times          | throughput       | discriminative or descriptive |
|                                |   |  | time from physician assessment to disposition decision (admission or discharge) | not described  | ED times          | throughput       | discriminative or descriptive |

## APPENDIX 8: Classification of Studies according to Variables under Study

### Country

**US (79):** 3, 4, 7, 23, 40, 44, 46–49, 51–54, 56, 58, 62, 66, 67, 70, 71, 74, 76–81, 83, 85, 86, 88, 95, 98, 100, 101, 107, 109–111, 115, 119–122, 125, 127, 128, 130–132, 138–141, 151, 153, 155, 156, 159–163, 172, 175–177, 179, 180, 182, 184, 187–192

**Canada (36):** 2, 31, 35, 36, 39, 42, 55, 57, 61, 65, 68, 69, 75, 87, 91–93, 97, 103, 104, 106, 113, 114, 117, 136, 164, 165–171, 185, 186, 193

**Australia (20):** 24, 27, 59, 63, 64, 84, 90, 96, 99, 105, 126, 143–150, 183

**UK (12):** 72, 73, 82, 102, 108, 123, 129, 137, 152, 174, 178, 181

**Spain (9):** 6, 50, 89, 94, 134, 133, 135, 157, 158

**Other (13):** 37, 38, 41, 43, 45, 60, 112, 116, 124, 118, 142, 154, 173

### Design

**Before-and-after study (52):** 39, 41, 42, 53, 56, 57, 59, 60, 62, 64, 66, 67, 72, 74, 77, 82, 88, 91–93, 105, 106, 110, 111, 114, 115, 118, 119, 121, 124, 125, 129, 130, 135, 137, 139, 151, 152, 154, 155, 157–159, 160, 164, 172, 174, 177, 180, 183, 187, 188

**Prospective cohort study (40):** 6, 7, 27, 36, 37, 31, 43, 46, 47, 49, 51, 52, 54, 58, 65, 68, 75, 81, 85–87, 89, 90, 98, 101, 109, 112, 120, 127, 133, 134, 141, 145, 147, 165, 167, 173, 175, 185, 189

**Retrospective cohort study (38):** 24, 48, 61, 63, 69, 73, 76, 83, 84, 96, 97, 100, 103, 104, 113, 126, 128, 131, 132, 142, 143, 146, 148–150, 153, 161, 166, 168–171, 186, 190–192, 193

**Cross-sectional study (18):** 3, 23, 30, 35, 38, 40, 44, 78–80, 94, 99, 122, 140, 162, 179, 182, 184

**Controlled trial (9):** 45, 102, 107, 116, 138, 156, 176, 178, 181

**Computer simulation model (8):** 50, 55, 70, 71, 95, 108, 123, 163

**Qualitative or Delphi study (2):** 2, 4

**Randomized controlled trial (2):** 117, 136

### Number of sites

**Single centre (124):** 4, 6, 7, 9, 24, 27, 30, 31, 37–39, 41, 45, 48–60, 62, 65, 66, 67, 69–72, 76–78, 81, 82–84, 86–95, 97, 98, 101–119, 120, 123–125, 127–136, 138, 139, 141–149, 151–155, 157–159, 163, 165, 167, 169, 172–178, 180, 181, 183, 185, 186, 189, 191–193

**Multicentre (45):** 2, 3, 4, 23, 35, 36, 40, 42–44, 46, 47, 61, 63, 64, 68, 73, 75, 79, 80, 85, 96, 99, 100, 121, 122, 126, 137, 140, 150, 156, 160–162, 164, 166, 168, 170, 171, 179, 182, 184, 187, 188, 190

### Operational definition of ED overcrowding

**Definition provided (52):** 2, 3, 6, 7, 24, 27, 30, 31, 40, 43, 44, 58, 79, 80, 83–85, 89–91, 94, 97, 100, 120, 122, 126, 128, 133–135, 141–143, 145, 147–150, 157, 162, 164, 165–169, 171, 173, 179, 182, 184, 191

**Definition not provided (117):** 4, 23, 35–39, 41, 42, 45–53, 54, 55, 56, 57, 59, 60–78, 81, 82, 86–88, 92, 93, 95, 96, 98, 99, 101–119, 121, 124, 125, 127, 129, 130–132, 136–140, 144, 146, 151–156, 158–161, 163, 170, 172, 174–178, 180, 181, 183, 185–190, 192, 193

### Measures to document ED overcrowding

**ED times (102 studies, 292 measures):** 2, 4, 23, 30, 31, 38, 39, 41, 43–46, 48–51, 53–57, 59, 60, 62, 65–72, 76, 81–84, 87, 88, 92–96, 98–102, 105, 107–112, 116–119, 122–129, 131, 133, 135, 136,

138–140, 143, 146, 149–152, 156–159, 162, 165, 167, 171, 172, 174–178, 180, 182, 183, 185, 186, 189, 193

**ED volumes (overall) (67 studies, 85 measures):** 2, 4, 6, 23, 24, 27, 30, 37, 38, 40, 43, 44, 46–48, 51, 58, 60–62, 67, 75, 79, 81, 83, 84, 87, 89–91, 94, 97, 106, 110, 112, 115, 118, 119, 121–123, 131–135, 138, 146, 148, 149, 151, 154, 157, 158, 160, 164, 167, 170, 175, 177, 179, 182, 186–188, 190, 191

**ED patient waiting volumes (23 studies, 65 measures):** 3, 4, 23, 24, 30, 37, 38, 43, 44, 48, 55, 60, 62, 70, 72, 79, 80, 81, 83, 84, 86, 87, 90, 91, 94, 97, 110, 112, 114, 115, 122, 133–135, 137, 138, 149, 151, 154, 160, 162, 164, 171, 179, 181, 186–188

**ED administration (22 studies, 59 measures):** 3, 4, 7, 23, 27, 30, 46, 78, 79, 80, 89, 84, 100, 108, 122, 141, 146–148, 162, 191

**ED patient volumes (32 studies, 56 measures):** 3, 23, 24, 27, 30, 38, 47, 50, 63, 65, 66, 68, 73, 79, 80, 86, 89, 90, 97, 104, 105, 113, 122, 133, 135, 142, 148, 152, 162, 173, 175, 178

**Access block (33 studies, 52 measures):** 2, 4, 23, 30, 31, 40, 44, 46, 47, 51, 53, 63, 64, 86, 91, 96, 113, 114, 122, 133, 135, 137, 143, 146, 148, 149, 161, 162, 165, 167, 182, 184

**Ambulance diversion (34 studies, 52 measures):** 4, 23, 30, 31, 42, 46, 47, 51, 58, 63, 64, 85, 86, 90, 91, 115, 120, 121, 131, 157, 161, 162, 164–169, 171, 182, 184, 187, 188, 190

**Left without being seen (39 studies, 40 measures):** 4, 27, 46, 49, 53, 54, 56, 61, 62, 68, 74, 77, 83, 84, 93, 99, 103, 104–106, 110, 115, 119, 127, 131, 132, 134, 135, 138, 139, 150, 155, 157, 158, 172, 177, 184, 189, 191

**ED length of stay (29 studies, 31 measures):** 30, 35, 36, 43, 45, 47, 52, 67, 69, 75, 96, 97, 103, 104, 106, 113, 114, 130, 144, 145, 147, 153–155, 158, 162, 163, 174, 192

**Left against medical advice (3 studies, 3 measures):** 68, 131, 155

### Category of measures

**Throughput (146 studies, 499 measures):** 2–4, 7, 23, 24, 27, 30, 31, 35–39, 41, 43, 45–57, 59–63, 65–77, 79–84, 86–90, 92–119, 122–124, 126–136, 138–159, 162, 163, 165, 167, 171–185, 189, 191–193

**Input (80 studies, 143 measures):** 2, 4, 6, 23, 24, 27, 30, 31, 37, 38, 40, 42–44, 46–48, 51, 58, 60–64, 67, 68, 71, 79, 83–87, 89–91, 94, 97, 100, 106, 110, 112, 115, 118–123, 131, 133, 135, 146, 148, 149, 151, 154, 157, 158, 160–162, 164–171, 175, 177, 179, 182, 184, 186–188, 190, 191

**Output (45 studies, 87 measures):** 2, 4, 23, 30, 31, 40, 44, 46, 47, 51, 53, 63, 64, 70, 76, 83, 84, 86, 90, 91, 96, 109, 110, 113, 114, 119, 122, 123, 127, 133, 135, 137, 143, 146, 148, 149, 152, 161, 162, 165, 167, 182, 184, 186, 193

**System (5 studies, 6 measures):** 46, 78, 89, 179, 191

### Purpose of measures

**Discriminative/descriptive (106 studies, 397 measures):** 3, 4, 7, 23, 24, 27, 30, 31, 35, 36, 37, 38, 40, 43, 44, 46, 48–51, 54, 58, 60–62, 65, 67, 68, 70, 71, 73, 75, 76, 78–81, 83–87, 89–91, 94–101, 104, 106, 108–110, 112, 119–123, 126–128, 131–135, 140–143, 145–150, 153, 158, 161–167, 169–171, 173, 175, 177, 179, 182, 184–186, 189–191, 193

**Evaluative (68 studies, 204 measures):** 39, 41, 42, 45, 53, 56, 57, 59, 60, 62–64, 66, 67, 69, 72, 74, 77, 82, 88, 91–93, 102, 103, 105–107, 110, 111, 113–119, 121, 124, 129, 130, 135–139, 151, 152, 154–160, 172, 174, 176–178, 180, 181, 183, 187, 188, 190, 192

**Predictive (38 studies, 134 measures):** 2, 6, 23, 27, 30, 31, 47, 51, 52, 54, 55, 58, 81, 86, 94, 108, 119, 122, 126, 131–134, 138, 143, 144, 146–150, 164, 165, 167, 168, 171, 191

## APPENDIX 9: First-round Delphi Questionnaire

### Measures of Overcrowding in Emergency Department

This survey is intended to obtain your opinion of measures or indicators of overcrowding. A good indicator or measure of overcrowding will change as a result of changes in the state of overcrowding in an ED. For example, the third measure in the survey, "total ED volume," is conceptualized in terms of the total number of patients in the ED including on stretchers, on chairs, in hallways, and in the waiting room. If the number of patients in the ED is a good indicator or measure, you should expect that this will change as the degree of overcrowding changes.

We intend to use the information you provide to compose a list, based on the perception of clinicians with experience in emergency care, which contains the key measures that should be reported to reflect the status of overcrowding in EDs across Canada. This survey has been approved by the University of Alberta Research Ethics Board Panel B. No individual respondents or institutions will be identified in the results of this survey.

The survey will take 10 to 15 minutes to complete. When you have finished, please save your copy of the survey using the original file name followed by \_and your initials (for example: Delphi form\_KB.doc). Return the file as an attachment to Ken Bond via e-mail ([kenneth.bond@ualberta.ca](mailto:kenneth.bond@ualberta.ca)) or complete the form, print it, and fax it to 780-407-6435.

Please read the following 36 measures and their associated definitions. Choose the rating from the drop-down list that best represents each measure's importance as an indicator of ED overcrowding. Also indicate whether your institution collects data for each measure.

| <b><i>ED patient volumes</i></b>   | <b>Importance of Measure</b> | <b>Does your institution collect data for this measure?</b>                                     |
|--|------------------------------|---|
| How important are each of the following measures of patient volume as indicators of ED overcrowding?                               |                              |   |
| 1. Patients in waiting room: number of patients occupying waiting room including those to be discharged                            | Click here to choose         | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 2. Patients at triage: number of patients who are awaiting triage  | Click here to choose         | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 3. Total ED patients: number of patients in ED including on stretchers, on chairs, in hallways, and in waiting room                | Click here to choose         | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 4. Total ED volume: number of patients presenting to ED over a set period (day, week, month, or year)                              | Click here to choose         | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 5. Percentage of time ED at or above stated capacity: percentage of time of day that ED has more patients than stated bed capacity | Click here to choose         | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| <b><i>ED times</i></b>   |                              |   |
| 7. Time from triage to placement: in minutes or hours from assignment of triage category to placement in treatment area            | Click here to choose         | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 8. Time from triage to bedside nurse: in minutes or hours from assignment of triage  | Click here to choose         | <input type="checkbox"/> Yes <input type="checkbox"/> No  |

|   |                      |   |
|---|----------------------|---|
| category to bedside nurse assessment  |                      | <input type="checkbox"/> Don't know   |
| 9. Time from triage to emergency physician (EP): in minutes or hours from assignment of triage category to examination by emergency physician   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 10. Time from EP assessment to disposition: in minutes or hours from beginning of emergency physician assessment to disposition (consult or admission or discharge)   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 11. Time from consult to disposition decision: in minutes or hours from beginning of consultant assessment to disposition (admit or discharge)  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 12. Time from bed request to bed assignment: in minutes or hours taken from admission decision to bed assignment (admitted patients only)   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 13. Time from bed ready to transfer to ward: in minutes or hours taken from admission assignment to leaving department (admitted patients only)   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 14. Time from waiting room to patient care area in ED: move from waiting room to patient care area in ED  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 15. Time from diagnostic imaging (DI) order to imaging done (stratified by DI modality such as X-ray, CT): from DI order to receipt of result in patient care area (excludes time taken for physician to recognize results are available) | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 16. Time from laboratory order to laboratory result returned: from laboratory order to receipt of result in patient care area (excludes time taken for physician to recognize result is available)  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 17. Longest time in ED for ED patient since registration: maximum time spent in ED from triage to assessment during previous 24 hours   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 18. Longest time in ED for admitted patient since admission during last 24 hours  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 19. Total time in ED (ED LOS): from first triage assessment to leaving department (to floor for admissions or discharge)  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| <b><i>Diversion status</i></b>  |                      |   |
| 20. Number of hours out of last 24 on ambulance diversion: situation in which ambulances are diverted away from ED and redirected to other hospitals  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 21. Percent of set time (day or month) spent on ambulance diversion   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |

| <b>ED staffing</b>  |                      |   |
|---|----------------------|---|
| 22. Number of ED nurses: hours per day of nursing coverage (e.g., 4 nurses working 12 hours each=48 hours per day)  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 23. Number of attending emergency physicians: hours per day of emergency physician coverage (e.g., 4 physicians working 8 hours each=32 hours per day)  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 24. Number of staffed acute-care beds: active beds staffed and "open" in hospital (does not relate to capacity to expand)   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 25. Overall bed occupancy: overall proportion of acute-care beds occupied by patients (measured on daily basis)   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 26. Average and range of patients per hour seen by EP: number of patients seen by EP during ED shift  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| <b>ED administration</b>  |                      |   |
| 27. Bed ratio: (current ED patients+predicted arrivals–predicted departures)/treatment areas  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 28. Provider ratio: arrivals per hour/sum of patients per hour for each physician   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 29. CTAS categories 2 and 3: using CTAS scoring system, this acuity measure would examine percentage of patients in CTAS categories 2 and 3.  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 30. CTAS categories 4 and 5: using CTAS scoring system, this acuity measure would examine percentage of patients in CTAS categories 4 and 5.  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 31. Admission proportions: overall proportion of emergency patients requiring admission to the hospital over period (month or year)   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 32. Hours of physician coverage per 1,000 patients seen or patients per hour of physician coverage: number of hours of physician coverage per 1,000 patients seen or patients per hour of physician coverage. | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 33. Left without being seen (LWBS): patients who leave before being seen by physician (usually after triage assignment by nurse)  | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| 34. Leave against medical advice (LAMA): patients who leave after being seen by physician, irrespective of admission status   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| <b>Measures of staff satisfaction or perception</b>   |                      |   |
| 35. Nurse satisfaction: assessment of satisfaction of nurses working in ED as to their perception of impact of ED overcrowding on care provided   | Click here to choose | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |

|   |  |   |
|---|--|---|
|   |  |   |
| 36. Physician satisfaction: assessment of satisfaction of emergency physicians working in ED as to their perception of impact of ED overcrowding on care provided   | Click here to choose                             | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| <p>Do you know of other measures that are good indicators of ED overcrowding, but that have not been listed here? Please type the indicator and its definition in the space provided below. Then, rate the measure. The boxes will expand to fit your text. This may offset the boxes, but it will not affect your ability to save or to return your responses.</p> |  |   |
|   | <b>Importance of Measure</b>                     | <b>Does your institution collect data for this measure?</b>                                     |
| <b>Measure:</b><br><b>Definition:</b>   | Click here to choose                             | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| <b>Measure:</b><br><b>Definition:</b>   | Click here to choose                             | <input type="checkbox"/> Yes <input type="checkbox"/> No<br><input type="checkbox"/> Don't know |
| <p><b>Please complete the following demographic information:</b></p>  |  |   |
| Age   | (Please type)                                    |   |
| Gender  | Click here to choose                             |   |
| Position  | Click here to choose<br>If other, please specify |   |
| Type of institution   | Click here to choose                             |   |
| ED visits per year  | (Please type)                                    |   |

## APPENDIX 10: Second-round Delphi Questionnaire

### Measures of Overcrowding in Emergency Department

Dear «Name»,

Thank you for the input you have provided to date regarding the indicators of overcrowding. The first-round survey had a response rate of 84%! This part of the project is intended to obtain your opinion on the relative importance of the resulting top 10 indicators of overcrowding from the first-round survey. As in the first round, we would like you to consider a good indicator of overcrowding as one that will change as a result of changes in the state of overcrowding in an ED.

We intend to use the information you provide to compose a list, based on the perception of clinicians with experience in emergency care, which contains the key indicators that should be reported to reflect the status of overcrowding in EDs across Canada. This survey has been approved by the University of Alberta Research Ethics Board. No individual respondents or institutions will be identified in the results of this survey.

When you have finished, please save your copy of the survey using the original file name followed by \_and your initials (for example: Delphi2\_KB.doc). Return the file as an attachment to Ken Bond via e-mail ([kenneth.bond@ualberta.ca](mailto:kenneth.bond@ualberta.ca)) or complete the form, print it, and fax it to 780-407-6435.

The following table lists the 10 indicators of ED overcrowding that were rated most highly by the panel of 32 key informants who completed the first-round survey. The indicators are listed in order from most highly rated to least highly rated, according to their mean rating. The name and operational definition has been repeated for each indicator, and for the mean rating for each indicator (based on the seven-point scale) and the rating you assigned to each indicator.

In the drop down box to the right of "How you rated this indicator" column, please assign each indicator a rank. This ranking will range from 1 to 10, where 1 means most important and 10 means least important; please use each number once. In the box furthest to the right, there is a space for comments. We would like you to give your reason for selecting the indicator that you rank as the most important and for the indicator that you rank as the least important. You may also comment on any other indicator that you choose.

## Relative importance of indicators of ED overcrowding

|   |                   |                              |      |           |
|---|-------------------|------------------------------|------|-----------|
| 1. Percentage of ED occupied by in-patients ("EIP") (indicator 6): percentage of patients in ED who have been admitted, but have not been transferred to ward because of lack of bed availability | Mean group rating | How you rated this indicator | Rank | Comments: |
|   | 6.53              | «q06»                        | ---  |           |
| 2. Total ED patients (indicator 3): number of patients in ED including on stretchers, on chairs, in hallways, and in waiting room   | Mean group rating | How you rated this indicator | Rank | Comments: |
|   | 6.35              | «q03»                        | ---  |           |
| 3. Overall bed occupancy (indicator 25): proportion of acute-care beds occupied by patients (indicated on daily basis)  | Mean group rating | How you rated this indicator | Rank | Comments: |
|   | 6.19              | «q25»                        | ---  |           |
| 4. Total time in ED (ED LOS) (indicator 19): from first triage assessment to leaving department (to floor for admissions or discharge)  | Mean group rating | How you rated this indicator | Rank | Comments: |
|   | 6.16              | «q19»                        | ---  |           |
| 5. Percentage of time ED at or above stated capacity (indicator 5): percentage of time of day that ED has more patients than stated bed capacity  | Mean group rating | How you rated this indicator | Rank | Comments: |
|   | 6.16              | «q05»                        | ---  |           |
| 6. Time from bed request to bed assignment (indicator 12): minutes or hours taken from admission decision to bed assignment (admitted patients only)  | Mean group rating | How you rated this indicator | Rank | Comments: |
|   | 6.06              | «q12»                        | ---  |           |
| 7. Time from triage to EP (indicator 9): minutes or hours from assignment of triage category to examination by emergency physician  | Mean group rating | How you rated this indicator | Rank | Comments: |
|   | 5.84              | «q09»                        | ---  |           |
| 8. MD satisfaction (indicator 36): assessment of satisfaction of EPs working in ED as to their perception of impact of ED overcrowding on care provided   | Mean group rating | How you rated this indicator | Rank | Comments: |
|   | 5.84              | «q36»                        | ---  |           |
| 9. Time from bed ready to transfer to ward (indicator 13): minutes or hours taken from admission assignment to leaving department (admitted patients only)  | Mean group rating | How you rated this indicator | Rank | Comments: |
|   | 5.53              | «q13»                        | ---  |           |
| 10. Number of staffed acute care beds (indicator 24): active beds staffed and "open" in hospital (does not relate to capacity to expand)  | Mean group rating | How you rated this indicator | Rank | Comments: |
|   | 5.53              | «q24»                        | ---  |           |