

APPENDIX 1: Electronic Databases Searched

DATABASE	PLATFORM	COVERAGE OF SEARCH	DATE OF SEARCH
MEDLINE®	Ovid Version: rel 9.1.0	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: rel 9.1.0	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: rel 9.1.0	1966 to November 14, 2004.	November 15, 2004 (updates on December 1, 2004 and December 09, 2004)
EMBASE	Ovid Version: rel 9.1.0	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: rel 9.1.0	1982 to November Week 1 2004	November 16, 2004 (updates on December 1, 2004 and December 09, 2004)
HealthSTAR/Ovid Healthstar	Ovid Version: rel 9.1.0	1975 to October 2004	November 16, 2004 (updates on December 1, 2004 and December 09, 2004)
PsycINFO®	Ovid Version: rel 9.1.0	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
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 -	November 16, 2004

DATABASE	PLATFORM	COVERAGE OF SEARCH	DATE OF SEARCH
		some full-text journals date back as far as 1965 or the first issue published.	
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 (http://www.informs.org/)	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) (http://www.osti.gov/graylit/)	November 2004	November 17, 2004
Dissertation Abstracts	ProQuest®	1980 to November 2004	November 17, 2004
NLM Gateway	U.S. National Library of Medicine - http://gateway.nlm.nih.gov/gw/Cmd	1950 to November 2004	November 17, 2004

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

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

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

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

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

DATABASE	SEARCH STRATEGIES
	<p>32. (("a and e" or "a & e" or a&e) adj1 (service\$ or department\$)).ti,ab. 33. ((emergenc\$ or emerg or accident\$ or casualt\$) adj2 (service\$ or department\$ or room\$ or centre\$ or center\$ or unit\$)).ti,ab. 34. ("acute care" or "emergency care").mp. 35. (emergicenter\$ or emergicentre\$).mp. 36. (((prehospital or pre-hospital) adj2 emergenc\$ adj2 care\$) or ("prehospital care" or "pre-hospital care")).mp. 37. (emergenc\$ adj2 (outpatient\$ or out-patient\$) adj2 unit\$).mp. 38. ((ems or ed or er) and emergenc\$).mp. 39. ("observation unit\$" or "observation area\$" or "holding unit\$" or "holding area\$").ti,ab. 40. "Canadian Triage & Acuity Scale".mp. 41. ambulance\$.ti,ab. 42. or/29-41 43. 28 and 42 44. remove duplicates from 43 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</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</p>

DATABASE	SEARCH STRATEGIES
KnowledgeSM)	care OR TS=acute care OR TS=emergency care OR TS=hospital emergenc* OR TS=emergency-department* OR TS=public hospital* emergenc* Results: 69
Academic Search Premier (EBSCOhost)	(((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)") AND (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") Results: 410
Social Sciences Abstracts (EBSCOhost)	(DE "Emergency medical services") or (DE "Emergency medical services--Conferences") or (DE "Triage (Medicine)") or ambulance* AND 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® CBCA Business (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") Results: 171
Business Source Premier	(((ZU "EMERGENCY MEDICAL SERVICES") or (ZU "EMERGENCY MEDICAL SERVICES -- COMMUNICATION SYSTEMS")) or (ZU "TRIAGE (MEDICINE)") or (ZU "TRAUMA CENTERS")) or (ZU

DATABASE	SEARCH STRATEGIES
(EBSCOhost)	<p>"AMBULANCE SERVICE") or (DE "HOSPITALS -- Emergency service")</p> <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 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")</p> <p>Results: 123</p>
INFORMS Online	<p>Emergency</p> <p>Results: 55</p>
<p>PAIS (Public Affairs Information Service) International</p> <p>(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=capacit* 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</p> <p>(ProQuest)</p>	<p>Overcrowding and emergency</p> <p>Patient flow</p> <p>Waiting time and emergency</p> <p>Results: 20</p>
<p>NLM Gateway</p> <p>(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 3: Form for the Inclusion and Exclusion of Studies

Interventions used to reduce overcrowding in emergency departments

Reference number: _____ Reviewer's initials: _____ Date: ____ / ____ / 2005
(dd) (mm)

1. TOPIC		
a) Is the primary issue in this study related to emergency department overcrowding? (Study must refer to overcrowding or one of its synonyms in the 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"/>
2. DESIGN		
Does the study satisfy any of the following designs?		Yes <input type="checkbox"/> No <input type="checkbox"/> Unsure <input type="checkbox"/>
RCT <input type="checkbox"/>	Case-control study <input type="checkbox"/>	
Quasi-randomized trial, or CCT <input type="checkbox"/>	Before-and-after study <input type="checkbox"/>	
Cohort study <input type="checkbox"/>		
3. INTERVENTION		
Does the study report on a specific intervention designed to reduce ED overcrowding?		Yes <input type="checkbox"/> No <input type="checkbox"/> Unsure <input type="checkbox"/>
4. CONTROL		
Does the study provide a comparison or control population with which to compare the intervention?		Yes <input type="checkbox"/> No <input type="checkbox"/> Unsure <input type="checkbox"/>
5. OUTCOME		
Does the study measure events related to ED overcrowding? These events can be any one or a combination of ED factors (waiting times), hospital related, but non-ED factors (access block), factors external to the hospital (ambulance diversion).		Yes <input type="checkbox"/> No <input type="checkbox"/> Unsure <input type="checkbox"/>
FINAL DECISION		
INCLUDE <input type="checkbox"/> (meets all criteria)	EXCLUDE <input type="checkbox"/> (fails to meet at least one criteria)	UNSURE <input type="checkbox"/> (need more data)
<input type="checkbox"/> Requires English translation	Study provides useful background information: Yes <input type="checkbox"/> No <input type="checkbox"/>	
If disagreement between reviewers, final outcome:		
INCLUDED <input type="checkbox"/> (meets all criteria)	EXCLUDED <input type="checkbox"/>	

APPENDIX 4: Quality Assessment Forms (Jadad Scale for RCTs)

Study number _____

Initials of assessor: _____

Part 1 (from: Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? Control Clin Trials 1996;17(1):1-12.)

- | | Score |
|---|-------|
| 1. Was the study described as randomized (this includes the use of words such as randomly, random, and randomization)?
Yes=1 No=0 | _____ |
| 2. Was the study described as double-blind?
Yes=1 No=0 | _____ |
| 3. Was there a description of withdrawals and drop-outs?
Yes=1 No=0 | _____ |

Add one point if:

Method to generate the sequence of randomization was described, and was appropriate (e.g., table of random numbers, computer-generated, coin-tossing)

Method of double-blinding was described, and was appropriate (identical placebo, active placebo, dummy)

Subtract one point if:

Method of randomization was described, and was inappropriate (allocated alternately, according to date of birth, hospital number)

Method of double-blinding described, but was inappropriate (comparison of tablet versus injection with no double dummy)

OVERALL SCORE (maximum 5)

APPENDIX 5: Quality Assessment Forms (Newcastle-Ottawa Quality Assessment Scale for Case-Control Studies)

A study can be awarded a maximum of one star for each numbered item in the selection and exposure categories. A maximum of two stars can be given for comparability.

Selection

1. Is case definition adequate?
 - a) yes, with independent validation*
 - b) yes (e.g., record linkage or based on self reports)
 - c) no description
2. Representativeness of cases
 - a) consecutive or obviously representative series of cases*
 - b) potential for selection biases or not stated
3. Selection of controls
 - a) community controls*
 - b) hospital controls
 - c) no description
4. Definition of controls
 - a) no history of disease (endpoint)*
 - b) no description of source

Comparability

1. Comparability of cases and controls on basis of design or analysis
 - a) study controls for _____ (select most important factor)*
 - b) study controls for any additional factor* (could be modified to indicate specific control for a second important factor)

Exposure

1. Ascertainment of exposure
 - a) secure record (e.g., surgical records)*
 - b) structured interview where blind to case control status*
 - c) interview not blinded to case control status
 - d) written self report or medical record only
 - e) no description
2. Same method of ascertainment for cases and controls
 - a) yes*
 - b) no
3. Non-response rate
 - a) same rate for both groups*
 - b) non-respondents described
 - c) rate different and no designation

APPENDIX 6: Quality Assessment Forms (Newcastle-Ottawa Quality Assessment Scale for Cohort Studies)

A study can be awarded a maximum of one star for each numbered item in the selection and outcome categories. A maximum of two stars can be given for comparability

Selection

1. Representativeness of exposed cohort
 - a) truly representative of average _____ (describe) in community*
 - b) somewhat representative of average _____ in community*
 - c) selected group of users (e.g., nurses, volunteers)
 - d) no description of derivation of cohort
2. Selection of non-exposed cohort
 - a) drawn from same community as exposed cohort*
 - b) drawn from different source
 - c) no description of derivation of non exposed cohort
3. Ascertainment of exposure
 - a) secure record (e.g., surgical records)*
 - b) structured interview
 - c) written self report
 - d) no description
4. Demonstration that outcome of interest was not present at start of study
 - a) yes*
 - b) no

Comparability

1. Comparability of cohorts on basis of design or analysis
 - a) study controls for _____ (select most important factor)*
 - b) study controls for any additional factor* (could be modified to indicate specific control for a second important factor)

Outcome

1. Assessment of outcome
 - a) independent blind assessment*
 - b) record linkage*
 - c) self report
 - d) no description
2. Was follow-up long enough for outcomes to occur?
 - a) yes (select an adequate follow-up period for outcome of interest)*
 - b) no
3. Adequacy of follow-up of cohorts
 - a) complete follow-up – all subjects accounted for*
 - b) subjects lost to follow-up unlikely to introduce bias – small number lost – > ____% (select adequate %) at follow-up, or description provided of those lost*
 - c) follow-up rate < ____% (select adequate %), and no description of those lost
 - d) no statement

APPENDIX 7: Quality Assessment Forms (Before-and-After Quality Assessment Tool)

Selection

1. Is post-intervention group representative?
 - a) consecutive or obviously representative series of participants from target population (YES)*
 - b) potential for selection biases or not stated (selected group of users) (NO)
 - c) no description of derivation of sample (UNCLEAR)
2. Is pre-intervention sample representative?
 - a) consecutive or obviously representative series of participants from target population (YES)*
 - b) potential for selection biases or not stated (selected group of users) (NO)
 - c) no description of derivation of sample (UNCLEAR)
3. Are pre- and post-intervention groups drawn from same source?
 - a) pre- and post-intervention groups drawn from same source (YES)*
 - b) pre- and post-intervention groups drawn from different source (NO)
 - c) no description of source of groups (UNCLEAR)

Comparability

4. Were pre- and post-intervention groups comparable on basis of design or analysis?
 - a) pre- and post-intervention groups are comparable regarding main characteristics (YES)*
 - b) analysis was adjusted for differences in pre- and post-intervention groups (YES)*
 - c) no attempt to control for differences between groups in design or the analysis (NO)
 - d) no description of comparability of pre- and post-intervention groups (UNCLEAR)

Assessment of outcome

5. Was assessment of outcome(s) valid?
 - a) confirmation of outcome by reference to secure records, or validated methods (YES)**
 - b) confirmation of outcome in sample of cases (YES)*
 - c) no confirmation or clearly non-validated outcome (NO)
 - d) no description (UNCLEAR)
6. Was assessment of outcome(s) reliable and accurate?
 - a) independent assessment of outcome by second reviewer in all cases (YES)**
 - b) independent assessment of outcome by second reviewer in sample of cases (YES)*
 - c) no confirmation of outcomes (NO)
 - d) no description (UNCLEAR)
7. Was method of outcome assessment the same for pre- and post-intervention groups?
 - a) YES*
 - b) NO
 - c) UNCLEAR

Intervention

8. Did study report point in time when intervention occurred?
 - a) study reported that intervention occurred at clearly defined point in time (YES)*
 - b) study reported that intervention did not occur at clearly defined point in time, or not reported in paper (NO)
9. Was intervention clearly described?
 - a) YES*
 - b) NO

Pre- and post-intervention periods

- 10) Were data collected during similar timeframe?

- a) pre- and post-intervention periods for study are the same (e.g., June 1 to 30, 2004, and June 1 to 30, 2005) (YES)**
- b) pre- and post-intervention duration, however, seasonal bias may have occurred (e.g. June 1 to 30, 2004, and July 1 to 30, 2004) (YES)*
- c) data collection during pre- and post-intervention periods for study not conducted during similar timeframes (e.g., June 1 to December 30, 2004, and January 1 to May 30, 2005) (NO)
- d) unclear in paper (e.g., dates of collection not mentioned in text) (UNCLEAR)

APPENDIX 8: Excluded Articles and Reason for Exclusion

No control group (4)

1. Ganapathy S, Zwemer FL. Coping with a crowded ED: an expanded unique role for midlevel providers. *Am J Emerg Med* 2003; 21(2):125-8.
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Computer simulation models (6)

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Not an intervention study (93)

1. Afilalo M, Boivin JF, Beigue M, Colacone A, Dankoff J, Giguere C *et al.* Developpement et evaluation d'une mesure de lourdeur de la clientele des departements d'urgence. Ottawa : Canadian Health Services Research Foundation, 2001. Available from: http://www.chsrf.ca/final_research/ogc/afilalo2_f.php?mode=print&.
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11. Baer RB, Pasternack JS, Zwemer FL. Recently discharged inpatients as a source of emergency department overcrowding. *Acad Emerg Med* 2001; 8(11):1091-4.
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APPENDIX 9: Articles Awaiting Assessment

Pending translation

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Pending retrieval

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APPENDIX 10: Study Characteristics

Country	n	
US	29	26 28 34 38 40 41 46 51 54 56 57 63 67-69 71 73 76 77 80-86 88-90
Canada	13	25 75 49 44 50 62 30 45 32 78 79 47 87
UK	9	27 29 72 53 33 36 42 43
Australia	5	48 59 60 31 58
Spain	3	35 52 55
Other	7	37 74 39 61 64-66
Intervention	n	
Fast track	23	37 25 26 44 27 28 29 30 45 31 32 38 39 47 40 33 34 35 36 41 42 43 46
Multi-faceted	12	59 48 49 50-52 53 54 55 56 57 58
Staff	8	60 61 62 85 64 66 67
Specific process	8	83 84 85 86 87 88 89 90
Triage	6	68 69 72 70 71 73
Diversions	4	74 75 76 77
Physician order entry	3	78 79 80
Short stay unit	2	81 82
Intervention type	n	
Single	50	74 75 37 81 83 25 61 68 59 26 44 27 28 69 29 84 72 45 31 32 38 63 85 78 79 82 39 47 64 65 86 70 80 87 40 71 33 66 34 73 35 88 89 36 41 42 90 43 67 46
Composite	16	60 48 49 50 62 30 51 76 52 53 54 55 56 57 58 77
Study design	n	
Before-and-after	50	75 81 83 25 60 61 68 59 48 49 26 27 28 69 29 84 50 62 30 31 32 63 85 79 82 64 51 76 65 86 70 80 52 53 71 54 33 66 34 55 35 88 89 56 36 57 90 58 67 77
Controlled trial	7	37 72 39 40 73 42 43
Cohort	7	74 44 45 38 78 41 46
Randomized controlled trial	2	47 87
Number of sites	n	
Single centre	57	74 37 81 83 25 60 61 68 49 26 44 27 28 69 29 84 50 62 30 72 45 31 32 38 63 85 78 79 82 39 47 64 51 65 86 70 80 52 87 40 71 54 33 66 34 55 35 88 56 36 41 57 42 90 43 58 46
Multicentre	9	75 59 48 76 53 73 89 67 77
Mechanism	n	
Throughput	51	74 37 83 25 60 61 68 26 44 27 28 29 84 62 30 72 45 31 32 38 63 78 79 82 39 47 64 51 65 86 70 80 52 87 40 71 54 33 66 34 73 55 35 88 36 41 57 42 90 43 46
Input	4	75 69 89 77
System-wide	4	59 49 76 53
Output	3	81 50 85
Throughput-output	3	48 56 58
Input-throughput	1	67
Annual ED census	n	
>50,000	25	37 81 25 68 49 27 69 50 62 30 72 31 82 47 64 65 86 80 40 33 66 34 55 56 36 43
<50,000	19	60 61 26 45 38 63 85 39 51 87 71 54 73 41 57 90 58 67 46
Not reported	21	74 75 83 59 48 44 28 29 84 32 78 79 76 70 52 53 35 88 89 42 77
Reported outcomes	n	
ED length of stay	34	37 81 61 49 26 44 84 62 30 45 31 32 38 63 78 79 39 47 51 86 80 87 40 54 33 66 34 55 35 56 41 57 42 58 46
Time to be seen	27	74 37 25 60 61 68 59 26 27 84 72 45 31 63 64 51 65 70 52 71 33 73 35 56 36 42 43
Left without being seen	20	81 83 68 28 69 30 45 31 32 63 82 51 52 40 71 34 55 35 56 57
Wait for admission	9	81 68 48 29 85 78 52 53 33
Diversions	7	75 59 48 82 76 67 77
Other	32	81 83 60 61 68 59 49 44 84 50 45 63 64 51 65 86 52 53 71 33 34 73 55 88 89 56 57 42 90 43 67 77

APPENDIX 11: Characteristics of Included Studies

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Anantharaman ⁷⁴	Singapore	retrospective cohort study	single centre, ED census: not reported	Diversion: comprehensive electronic ambulance case record (HEAL system). Setting of intervention: throughput	October 1998 to January 1999	waiting time for critical care patients to be seen at ED	waiting time for critical care patients to be seen in ED decreased if brought by HEAL ambulances	NOS=5/9
Anderson ⁷⁵	Canada	before-and-after study	multicentre ED census: not reported	Diversion: new system for ambulance diversion (total redirect and critical care bypass). Setting of intervention: input	February to June 1999	percent of available time on diversion	reductions in percent of available time spent on diversion	BAQA=6/14
Ardagh ³⁷	New Zealand	controlled trial	Single centre, ED census: 65,000+ visits per year	Fast track: rapid assessment clinic (RAC): additional nurse and doctor rostered to run RAC. Setting of intervention: throughput	February to April 2000	length of time in ED; waiting time to be seen by doctor	rapid assessment clinic reduced waiting times to see doctor and time in ED for lower triage categories	Jadad=1/5
Bazarian ⁸¹	US	before-and-after study	single centre, ED census: 60,000 visits per year	Short stay: short-stay in-patient medicine unit. Setting of intervention: output	August to November 1994	number of patients boarded in ED; ED LOS; average number of hours spent in ED by treat-and-release patients; number of patients who LWBS; number of patients treated and released with LOS >8 hours	decrease in interval that treat-and-release patients spend in ED	BAQA=9/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Boger ⁸³	US	before-and-after study	single centre, ED census: not reported	Specific process: electronic tracking board. Setting of intervention: throughput	October to December 2000	waiting time to treatment area; number of patients who LWBS	use of electronic tracking board decreased LOS and number of LWBS; improvements in patients' satisfaction and number of ED patients waiting in 4 to 6 hour range	BAQA=4/14
Bond ²⁵	Canada	before-and-after study	single centre, ED census: 68,000 visits per year	Fast track: physician and nurse staffed assessment room for non-urgent patients. Setting of intervention: throughput	not reported	mean waiting times for non-urgent patients	decrease in mean waiting times for non-urgent patients	BAQA=7/14
Browne ⁶⁰	Australia	before-and-after study	single centre, ED census: 46,000 visits per year	Staff: seamless model of management (hospital restructure). Setting of intervention: throughput	July 1998 to June 1999	waiting times; critical care performance	Seamless model of management improved average waiting time, critical care performance, patient satisfaction, staff morale, and waiting time for ambulatory patients presenting to ED	BAQA=7/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Bucheli ⁶¹	Switzerland	before-and-after study	single centre, ED census: 34,000 visits per year	Staff: adding second physician on shift. Setting of intervention: throughput	not reported	waiting time from ED entry after registration to first medical procedure; waiting time from ED entry to start of history taking and physical examination; duration of ED patient examination; time per hour and per physician for activities other than patient examination; total ED LOS	addition of physician to the evening shifts decreased LOS for outpatients discharged after evaluation and management in ED, but not for ED in-patients admitted for hospitalization	BAQA =9/14
Cain ⁶⁸	US	before-and-after study	single centre, ED census: 65,000 visits per year	Triage: pediatric triage criteria modification. Setting of intervention: throughput	November 1992 to January 1993	waiting time to ED examination; waiting time to ED disposition; time to floor admission from ED; time to intensive care unit admission from ED	altering pediatric triage criteria increased triage acuity level of children presenting to ED, decreased waiting times to physician examination and admission, and decreased amount of “undertriage”; improvements had no adverse effect on adult patient flow	BAQA =8/14
Cameron ⁵⁹	Australia	before-and-after study	multicentre ED census: not reported	Multi-faceted: emergency service enhancement program (bonus payments made to public hospitals to improve access to care for patients attending EDs). Setting of intervention: system-wide	April 1995 to June 1998	number of episodes of ambulance bypass; proportion of patients receiving attention within threshold time; access block	reduction in number of ambulance diversion episodes per quarter; improved ability to adhere to waiting time thresholds	BAQA =8/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Cameron ⁴⁸	Australia	before-and-after study	multicentre ED census: not reported	Multi-faceted: organizational change to implement 51 actions and improve patients' access (emergency demand management, elective surgery, capacity management, subacute processes). Setting of intervention: throughput-output	June to September 2001	ambulance bypass; emergency patients waiting >12 hours for in-patient bed	reduction in number of episodes of ambulance diversion; reduction in number of patients waiting >12 hours	BAQA =6/14
Cardin ⁴⁹	Canada	before-and-after study	single centre, ED census: 50,000 visits per year	Multi-faceted: increased emergency physician coverage; designation of physician coordinators; new hospital policies regarding laboratory, consultation, and admission procedures. Setting of intervention: system-wide	October 1993 to October 1994	rate of stretcher occupancy; mean LOS for patients discharged from ED; average LOS of all ED patients	reduced mean LOS for patients discharged from ED without resulting in increased return visits to ED	BAQA =9/14
Chan ²⁶	US	before-and-after study	single centre, ED census: 40,000 visits per year	Fast track: accelerated care at triage (rapid ED entry with automated electronic registration, and immediate patient identification bar coding technology, with option of physician evaluation and ancillary testing on patient arrival). Setting of intervention: throughput	August to November 2003	mean ED LOS; waiting time for fast track patients; waiting time for admitted patients; waiting time for non-admitted patients	accelerated care at triage reduced overall LOS and waiting times for fast track and non-admitted patients; no changes in waiting times for admitted patients	BAQA =5/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Cheung ⁴⁴	Canada	retrospective cohort study	single centre, ED census: not reported	Fast track: advance triage system (triage nurse's initiation of appropriate diagnostic tests for eligible patients based on established set of protocols or algorithms). Setting of intervention: throughput	1997	total LOS; LOS after physician assessment	advanced triage system reduced total ED LOS; most significant saving was realized in LOS after physician assessment	NOS=5/9
Cooke ²⁷	UK	before-and-after study	single centre, ED census: 13,918 visits in 10 weeks	Fast track: doctor based in desk-type consulting room (fast track room) saw ambulant patients with injuries not requiring examination couch or urgent intervention. Setting of intervention: throughput	not reported	proportion of patients waiting <30 minutes to see doctor; proportion of patients waiting <60 minutes to see doctor; waiting time	introduction of separate stream for minor injuries can produce improvement in number of trauma patients waiting >60 minutes	BAQA =7/14
Covington ²⁸	US	before-and-after study	single centre, ED census: not reported	Fast track: nurse practitioner-staffed fast track. Setting of intervention: throughput	January 1990 to September 1991	number of patients who LWBS	reduction in number of patients who LWBS	BAQA =3/14
Derlet ⁶⁹	US	before-and-after study	single centre, ED census: 60,000 visits per year	Triage: policy of triaging patients out of ED. Setting of intervention: input	July 1988 to June 1991	patients who LWBS	new triage system reduced number of patients who LWBS; unnecessary to provide treatment to all patients presenting to ED; patients can be referred away provided there is enough community support	BAQA =5/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Dinah ²⁹	UK	before-and-after study	single centre, ED census: not reported	Fast track: fast track. Setting of intervention: throughput	May to July 2001	waiting time	fast track system significantly reduced mean waiting times and variability of these waiting times	BAQA =9/14
Espinosa ⁸⁴	US	before-and-after study	single centre, ED census: not reported	Specific process: re-engineering of ED radiology services (all films brought directly to emergency medicine physicians for interpretation), radiology technical staff dedicated to ED. Setting of intervention: throughput	May 1996	turnaround time; fast track cycle time; time from arrival to treatment; overall LOS	X-ray turnaround time, fast track cycle time, arrival to treatment by emergency physician, and overall ED LOS reduced; patient satisfaction with waiting time increased	BAQA =7/14
Feferman ⁵⁰	Canada	before-and-after study	single centre, ED census: 80,000 visits per year	Multi-faceted: creation of geriatric unit to assess and care for increasing number of elderly and chronic care patients; bed reallocation in services; more beds for medical services; increase in outpatient surgeries; expansion of short-stay and ambulatory procedures units; implementation of physician-managed admission system. Setting of intervention: output	October 1987 to March 1988	number of times ED is closed to patients arriving by ambulance; number of patients waiting in ED for admission; number of geriatric patients waiting for transfer to long-term care; number of patients seen in short-stay and ambulatory procedures units	intervention resulted in significant decrease in number of times ED went on ambulance diversion	BAQA =9/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Fernandes ⁶²	Canada	before-and-after study	single centre, ED census: 50,000 visits per year	Staff: continuous quality improvement (CQI) with addition of admission clerk, and reduction of fast track nurse function to include only patient placement and vital signs. Setting of intervention: throughput	January to February 1994	ED LOS	formal application of continuous quality improvement techniques in ED produced significant reductions in chart generation times, and LOS for fast-track patients	BAQA =6/14
Fernandes ³⁰	Canada	before-and-after study	single centre, ED census: 4,553 in one month before intervention	Fast track: five solutions developed with CQI process to facilitate patient flow through triage and fast track areas: extra admitting clerk, streamlined fast track process, expanded fast track area, more detailed triage classification. Setting of intervention: throughput	not reported	ED LOS; patients who LWBS	significant decrease in proportion of patients who LWBS	BAQA =7/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
George ⁷²	UK	controlled trial	single centre, ED census: 60,000 visits per year	Triage: formal nurse triage versus informal prioritization process. Setting of intervention: throughput	1990	waiting times	patients in triage group waited longer than those in no triage group; median waiting time significantly higher for urgent patients assigned to triage group; triage did not affect patient satisfaction; study failed to show benefits claimed for formal nurse triage; nurse triage may impose additional delay for patient treatment, particularly among patients needing most urgent attention	Jadad=1/5
Grafstein ⁴⁵	Canada	retrospective cohort study	single centre, ED census: 45,000 visits per year	Fast track: waiting room or hallway care versus triaged to acute care bed. Setting of intervention: throughput	November 2000 to November 2002	ED LOS; number of patients who LWBS; number of patients who left against medical advice (LAMA)	waiting room patients had shorter ED LOS and LWBS/LAMA more often	NOS=7/9
Grant ³¹	Australia	before-and-after study	single centre, ED census: 5,480 visits per month	Fast track: rapid assessment team (doctor and triage nurse). Setting of intervention: throughput	July to September 1997	number of patients seen within waiting time appropriate to their National Triage Scale classification; median waiting time; LOS; number of patients who did not wait to see doctor	number of patients who were seen within accepted time standards increased, and median waiting times reduced; no significant changes in median LOS	BAQA =8/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Hall ³²	Canada	before-and-after study	single centre, ED census: not reported	Fast track: fast track. Setting of intervention: throughput	not reported.	LOS; number of patients who LWBS	fast track in busy urban ED reduced LOS and number of patients who LWBS in CTAS category levels 3, 4, and 5	BAQA =5/14
Hampers ³⁸	US	prospective cohort study	single centre, ED census: 39,000 visits per year	Fast track: fast track in pediatric ED. Setting of intervention: throughput	September to December 1997	LOS	number of tests and LOS reduced; no differences in final outcomes or satisfaction detected between two study groups	NOS=6/9
Howell ⁶³	US	before-and-after study	single centre, ED census: 25,000 to 30,000 visits per year	Staff: dedicated physician staffing. Setting of intervention: throughput	December 1987 to March 1988	number of patients waiting >1 hour for disposition from ED; number of patients waiting >2 hours for disposition from ED; waiting time to be seen by physician; total time from entry to ED until disposition; number of patients who LWBS	addition of one residence-trained emergency physician and increase in overall emergency medicine experience of ED staff improved timeliness and quality of care; amount of time required to be seen by physician, time to discharge, number of patients who LWBS, and number of incomplete charts dropped significantly	BAQA =8/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Howell ⁸⁵	US	before-and-after study	single centre, ED census: 41,180 visits per year	Specific process: admission system based on telephone consultation between ED physicians and in-house hospital staff. Setting of intervention: output	January to February 2000	admission cycle time	using hospital staff, safe and efficient admission process significantly reduced admission times	BAQA =7/14
Innes ⁷⁸	Canada	retrospective cohort study	single centre, ED census: not reported	Physician order entry (POE): computerized physician order entry. Setting of intervention: throughput	June to October 2001	number of admitted patients held in ED; stretcher time; ED LOS; number of patients treated in hallways	ED overcrowding increased after POE: more patients treated in hallways, number of admitted patients held in ED and ED LOS for admitted patients increased; ED computerized POE reduced ED LOS, ED stretcher time, time from registration to medical examination, time from registration to laboratory order, and time from registration to get first result	NOS=6/9
Innes ⁷⁹	Canada	before-and-after study	single centre, ED census: not reported	POE: ED POE. Setting of intervention: throughput	June to November 2001	number of admitted patients held in ED; ED LOS for discharged patients; number of waiting room patients at ED; ED LOS for patients treated in waiting room	ED overcrowding and gridlock increased after POE; mean daily number of admitted patients held in ED, and ED LOS for admitted patients increased; increase in ED LOS for	BAQA =7/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
							discharged patients reduced; ED LOS for waiting room patients reduced; POE expedited patient care, and mitigated negative impact of overcrowding on ED LOS	
Kelen ⁸²	US	before-and-after study	single centre, ED census: 54,000 visits per year	Short stay: ED-managed acute care unit remote from main ED. Setting of intervention: throughput	January 2001	frequency of ambulance diversion; ambulance diversion; patient volumes; number of patients who LWBS	ED-managed acute care unit reduced number of patients who LWBS and ED diversion	BAQA =6/14
Kilic ³⁹	Turkey	controlled trial	single centre, ED census: 30,000 visits per year	Fast track: fast track. Setting of intervention: throughput	June to July 1997	ED LOS	median ED LOS decreased and patient satisfaction improved; fast tracking did not improve waiting times for patients with gastroenteritis and urinary tract infections	Jadad=0/5
Klassen ⁴⁷	Canada	randomized controlled trial	single centre, ED census: 55,000 visits per year	Fast track: radiograph ordering by ED nurses (using Brand protocol) for extremity trauma. Setting of intervention: throughput	March 1990 to February 1991	total time spent in ED	having triage nurses use Brand protocol reduced number of radiographs ordered but increased number of missed radiographic findings; ED waiting times also significantly shortened	Jadad=3/5

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Krakau ⁶⁴	Sweden	before-and-after study	single centre, ED census: 4,694 visits per month	Staff: implementation of general practitioner (GP) surgery in ED (addition of GP physicians without addition of other personnel). Setting of intervention: throughput	April 1994 to October 1995	ED patient volume; average waiting time for non-urgent patients; average waiting time for urgent cases	addition of GP physicians to ED increased number of visits, particularly for those with non-urgent complaints; addition of GP physicians to ED staff lessened delay for patients with non-urgent complaints but worsened delay for patients with urgent or emergent conditions	BAQA =8/14
Kyriacou ⁵¹	US	before-and-after study	single centre, ED census: 41,000 visits per year	Multi-faceted: administrative interventions (CQI techniques); automatic ordering of old medical records by ED clerk; nursing attendants assigned to take specimens to laboratory; printer installed in ED to print laboratory results; new beeper system for major consultation services; fast track for returning patients; radiology technicians transport patients to and from radiology unit; pneumatic tube system installed for transporting laboratory specimens; development of new discharge instructions; institution of one-stem	September 1993 to July 1998	time from disposition order to patient discharge from ED; total LOS; time from triage presentation to completion of registration; time from completion of registration to ED treatment area entry; time from ED treatment area entry to initial medical assessment; time from triage presentation to initial medical assessment; time from initial medical assessment to disposition order	significant reduction of median total ED LOS and improvements in overall efficiency (waiting times)	BAQA =6/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
				triage system. Setting of intervention: throughput				
Lagoe ⁷⁶	US	before-and-after study	multicentre ED census: not reported	Diversion: system-wide procedures involving exchange of information about diversion (EMSystem). Hospital-specific procedures: implementation of additional planning and criteria for implementing ambulance diversion and development of additional patient care resources. Setting of intervention: system-wide	January 2001 to June 2002	hours on ambulance diversion; ambulance transports received	multi-hospital approach reduced ambulance diversion hours and ambulance transports at community-wide and hospital-specific levels; substantial amounts of diversion time remained after these efforts	BAQA =9/14
Lau ⁶⁵	Hong Kong	before-and-after study	Single centre, ED census: 13,837 visits per month	Staff: small team consultation system. Setting of intervention: throughput	January to April 1994	waiting time	small team consultation system reduced average waiting time of patients; no significant changes in other variables affecting patients' waiting time and quality of service	BAQA =7/14
Lee-Lewandowski ⁸⁶	US	before-and-after study	Single centre, ED census: 70,000 visits per year	Specific: point-of-care testing in satellite laboratory in ED with dedicated laboratory staff and research nurse. Setting of intervention: throughput	not reported	ED LOS	significant decrease in in-laboratory turnaround times; significant decrease in LOS in ED for patients receiving point-of-care testing	BAQA =4/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Mallett ⁷⁰	UK	before-and-after study	single centre, ED census: not reported	Triage: triage. Setting of intervention: throughput	March 1988	time taken to see doctor; time taken to see health care professional (nurse); time to be seen by triage assessor; time spent in ED	Nurse triage enabled shorter waiting time between arrival and assessment of ED attender; introduction of nurse triage successful in reducing waiting time for patients to be clinically assessed	BAQA =8/14
McAfee ⁸⁰	US	before-and-after study	single centre, ED census: 52,555 visits per year	POE: computerized order entry system. Setting of intervention: throughput	June 2000 to June 2001	ED LOS	Implementation of computerized order entry system increased average LOS for ED patients	BAQA =6/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Miro ⁵²	Spain	before-and-after study	Single centre, ED census: not reported	Multi-faceted: structural ED reorganization; structural resources (cubicles); increase in initial assessment and treatment observation areas; increase in daily personnel average (consultants, residents, nurses, nurse assistants, sanitary assistants, administrative personnel). Setting of intervention: throughput	February 2000	number of patients being seen; number of patients waiting for doctor; number of patients waiting for test results; number of patients waiting for outcome; number of patients waiting for specialist; waiting time to be seen; number of patients who LWBS; number of patients waiting after being seen; number of patients waiting to go to inpatient bed; number of patients waiting to find inpatient bed; number of patients waiting for investigations outside ED; number of patients waiting for relatives; number of patients waiting for social assistant; number of patients waiting for ambulance; number of patients waiting to be seen	reduction in number of patients waiting to be seen and reduction in periods of overcrowding	BAQA =8/14
Murray ⁸⁷	Canada	randomized controlled trial	single centre, ED census: 41,000 visits per year	Specific process: point-of-care testing for selected laboratory tests. Setting of intervention: throughput	May to September 1997	ED LOS	intervention produced reductions in median LOS; use of point-of-care testing can achieve significant time savings in ED	Jadad=2/5

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
NHS Modernisation Agency ⁵³	UK	before-and-after study	multicentre ED census: not reported	Multi-faceted: National Patients Access Team (NPAT) program; trolley wait program to identify and address bottlenecks in ED (practice guidelines). Setting of intervention: system-wide	October 2000 to March 2001	number of >12 hour trolley waits; average number of 4- to 12-hour trolley waits; percentage of ED admissions waiting >4 hours; percentage of patients waiting over target waiting time from decision to admit to admission; percentage of patients waiting over target waiting time for ED triage; percentage of patients waiting over target waiting time from triage to examination by ED staff; percentage of patients waiting over target waiting time from examination to decision to admit; percentage of delayed discharges	reduced number of 12-hour trolley waits, and reduced percentage of ED admissions waiting >4 hours	BAQA =9/14
Partovi ⁴⁰	US	controlled trial	single centre, ED census: 52,000 visits per year	Fast track: faculty (senior physician) triage. Setting of intervention: throughput	August to November 1999	ED LOS; patients who LWBS	faculty triage moderately increased efficiency, albeit with relatively high cost; fast track significantly reduced ED LOS; no significant reductions found in number of LWBS	Jadad=0/5
Paulson ⁷¹	US	before-and-after study	single centre, ED census: 3,200 visits per month	Triage: triage systems that use nurses versus unlicensed assistive personnel. Setting of intervention: throughput	not reported	waiting time; triage time; treatment time; number of patients who LWBS	waiting time after triage and number of patients LWBS reduced	BAQA =8/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Rinderer ⁵⁴	US	before-and-after study	single centre, ED census: 33,000 visits per year	Multi-faceted: quality improvement approach; additional rooms; additional registered nurses; additional health unit coordinator; additional pharmacy hours; non-patient registered charge nurse; autohold policy; dedicated radiology technician; primary care nursing; dedicated laboratory technician; private triage room. Setting of intervention: throughput	not reported	ED patients volume; LOS per visit	reduction in average LOS	BAQA =7/14
Rogers ³³	UK	before-and-after study	single centre, ED census: 59,000 visits per year	Fast track: “see and treat” system; one clinician able to see, treat, and discharge patient after initial assessment. Setting of intervention: throughput	November to December 2002	percentage of patients discharged in 4 hours; percentage of patients admitted in 4 hours percentage of patients triaged within 15 minutes percentage of patients seen within 1 hour of arrival; percentage of patients discharged within 1 hour; time to see doctor or emergency nurse; average total time in ED	introduction of “see and treat” reduced waiting times for those with minor injuries and illnesses, and had positive impact on patients in higher categories	BAQA =8/14
Rotstein ⁶⁶	Israel	before-and-after study	single centre, ED census: 4,800 visits per month	Staff: adding physician during evening shift (administrative change). Setting of intervention: throughput	October 1993 to March 1995	ED LOS	addition of physician to ED staff reduced LOS for 80 to 119 admissions; adding physician for <80 or >120 admissions did not reduce LOS in ED	BAQA =7/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Ruoff ³⁴	US	before-and-after study	single centre, ED census: 216 visits per weekday	Fast track: physician triage. Setting of intervention: throughput	not reported	daily elopement rates (patients who LWBS); LAMA rates; ED LOS	physician-assisted triage reduced overall LOS; no changes in patients LWBS, AMA, or LOS on weekends; patients' satisfaction increased	BAQA =4/14
Ryan ⁷³	US	controlled trial	multicentre ED census: hospital A: 5,575 visits in 7 weeks; hospital B: 4,548 visits in 7 weeks	Triage: formal triage system. Setting of intervention: throughput	November to December 1993	waiting time to see doctor; waiting time to see nurse	use of formal triage system increased mean waiting time to see doctor and mean waiting time to see nurse for non-urgent cases; in medium-sized EDs, triage does not seem to reduce waiting times for cases designated "semi-urgent" or "delay acceptable"	Jadad=2/5
Salazar ⁵⁵	Spain	before-and-after study	single centre, ED census: 100,000 visits per year	Multi-faceted: opening of ED short-stay unit and opening of hospital holding unit for patients waiting to be admitted to hospital service; increase number of ED attending physicians and reorganization of their task; automated database system; direct supervision of hospital medical managers at ED. Setting of intervention: throughput	December 1999 to January 2000	number of diversions to other hospitals; average daily attendance rate; mean total patients' LOS at ED; number of patients who LWBS	significant reduction in LOS and patients LWBS	BAQA =6/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Sanchez ³⁵	Spain	before-and-after study	Single centre, ED census: not reported	Fast track: fast track. Setting of intervention: throughput	February 2002 to January 2003	waiting time to be seen; LOS	Fast track area able to improve ED performance by means of decreasing waiting time, LOS, and patients LWBS	BAQA =8/14
Saxena ⁸⁸	US	before-and-after study	Single centre, ED census: not reported	Specific process: dedicated stat laboratory. Setting of intervention: throughput	not reported	turnaround acknowledging time (postanalytic phase); within laboratory turnaround; collecting time (preanalytic phase); sending time (preanalytic phase); transporting time (preanalytic phase); accessioning time (preanalytic phase); processing time (analytic phase); analyzing time (analytic phase); computing time (analytic phase)	improvements in median within-laboratory turnaround times (ordering, specimen collection, arrival in laboratory, accessioning complete blood count, transportation time); no changes in median preanalytic delays and analytic phase	BAQA =3/14
Schaefer ⁸⁹	US	before-and-after study	multicentre ED census: not reported	Specific process: EMS-based alternative care destination program for patients with low acuity diagnosis codes (clinic-based destination as alternative to ED). Setting of intervention: input	August 2000 to January 2001	number of ED visits	proportion of patients who received care in ED decreased	BAQA =9/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Sedlak ⁵⁶	US	before-and-after study	single centre, ED census: 53,000 visits per year	Multi-faceted: changes on bedside registration, hardwired checkout, dedicated radiology transport technician, centralized bed control, ED physician admit authority. Setting of intervention: throughput-output	January to December 2003	overall ED LOS; time from arrival to time to be seen by doctor; time from order input to examination; time from order input to interpreted results in the ED; time spent by ED patients waiting for radiological examinations; number of patients who LWBS; time from arrival to time to ED bed placement	reduction in time from arrival to being seen by doctor and average overall LOS	BAQA =2/14
Shrimpling ³⁶	UK	before-and-after study	single centre, ED census: 60,000 visits per year	Fast track: redesign of triage system (minor injuries team). Setting of intervention: throughput	November to December 2001	total time in ED; total time spent with ED practitioners; waiting times throughout ED; proportion of patients seen within 30 minutes; proportion of patients seen within 60 minutes	significant decrease in waiting times for all ED attenders; change in practice shown to be satisfactory and clinically safe	BAQA =5/14
Simon ⁴¹	US	retrospective cohort study	single centre, ED census: 33,000 visits per year	Fast track: fast track. Setting of intervention: throughput	December 1993 to August 1994	turnaround time	flow of lower acuity patients was increased without compromising patient care and allowed pediatric emergency physicians to see greater proportion of higher acuity patients	NOS=6/9

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Spaite ⁵⁷	US	before-and-after study	single centre, ED census: 48,000 visits per year	Multi-faceted: to name senior faculty member from division of emergency medicine as administrative director of ED; changes in staffing, triage registration, diagnostic radiology, laboratory, bed availability. Setting of intervention: throughput	May to December 1998	median patient waiting room time interval; ED throughput times; number of patients who LWBS; laboratory delay; radiology delay	decreases in waiting room times, ED throughput times, and urgent care waiting room times	BAQA =6/14
Subash ⁴²	UK	controlled trial	Single centre, ED census: not reported	Fast track: team triage (doctor and nurse). Setting of intervention: throughput	not reported	number of patients treated and discharged within 20 minutes; time to triage; time to see doctor; time to radiology; time to discharge; time to nurse discharge	doctor-nurse triage teams significantly reduced triage times, time to see doctor, and time to radiology; significant increase in number of patients seen and discharged within 20 minutes	Jadad=2/5
Takakuwa ⁹⁰	US	before-and-after study	single centre, ED census: 3,037 visits per month	Specific process: bedside registration. Setting of intervention: throughput	November 2001 to March 2002	time from triage to room; time from room to disposition	changes in time from triage to room across all triage classifications; bed registration had no effect on mean time from room to disposition across all triage classifications	BAQA =6/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Terris ⁴³	UK	controlled trial	single centre, ED census: 108,000 visits per year	Fast track: impact team at triage (emergency medicine consultant and senior ED nurse). Setting of intervention: throughput	December 2001 to February 2002	number of patients waiting for triage; number of patients waiting for minors; number of patients waiting for majors; number of patients waiting to be seen (overall); number of patients waiting >4 hours to see doctor	significant reductions in number of patients waiting to see doctor or emergency nurse practitioner, especially for "minors"; overall reduction in number of patients waiting in ED at any one time; sense of improved patient flow	Jadad=1/5
Toncich ⁵⁸	Australia	before-and-after study	single centre, ED census: 42,000 visits per year	Multi-faceted: health care improvement changes (16 organizational changes); 3-hour computer ward rounds; fast track criteria developed; bed management team relocated next to ED; system for prioritization of X-rays; EDIS; resources reallocation; administrative changes. Setting of intervention: throughput-output	not reported	LOS for admitted patients; LOS for discharged patients; LOS for total ED patients	improvements in operational times not clinically or statistically significant	BAQA =7/14
Vilke ⁶⁷	US	before-and-after study	multicentre ED census: hospital A: 45,000 visits per year; hospital B: 39,000 visits per year	Staff: staying off ED diversion; collateral interventions included expanding physician coverage several hours per day, additional nursing and technician shift each day. Setting of intervention: input-throughput	not reported	diversion hours; number of diverted patients; ED census; ambulance runs	commitment to avoid ED ambulance diversion at one institution can obviate need for diversion at neighbouring facility.	BAQA =8/14

Study	Country	Design	Setting	Intervention	Study Period	Outcomes	Findings and Conclusions	Quality
Vilke ⁷⁷	US	before-and-after study	Multicentre ED census: not reported	Diversion: revision of community ambulance diversion guidelines. Setting of intervention: input	October to December 2002	time on diversion; number of diverted patients; bypass hours; ED visits	significant decrease in average monthly hours on diversion	BAQA =9/14
Winn ⁴⁶	US	retrospective cohort study	single centre, ED census: 18,000 visits per year	Fast track: triage nurse protocols for ordering of diagnostic tests. Setting of intervention: throughput	not reported	ED LOS	ED LOS significantly shorter; use of nurse protocols for ordering of diagnostic tests before patient is seen by physician may prove helpful in increasing efficiency in ED.	NOS=5/9

APPENDIX 12: Characteristics of Studies with Negative Results

Study	Country	Design	Setting	Intervention	Study Period	Negative Results
Grafstein ⁴⁵	Canada	retrospective cohort	single centre, ED census: 45,000 visits per year	fast track	November 2000 to November 2002	waiting time
Ardagh ³⁷	New Zealand	controlled trial	single centre, ED census: 65,000+ visits per year	fast track	February to April 2000	waiting time triage levels 1 and 2
Krakau ⁶⁴	Sweden	before-and-after	single centre, ED census: 4,694 visits per month	staffing	April 1994 to October 1995	waiting time urgent patients
Ryan ⁷³	US	controlled trial	multicentre ED census: hospital A, 5,575 visits in 7 weeks; hospital B, 4,548 visits in 7 weeks	triage	November to December 1993	waiting time
George ⁷²	UK	controlled trial	single centre, ED census: 60,000 visits per year	triage	1990	waiting time triage levels 1 to 4
Mallett ⁷⁰	UK	before-and-after	single centre, ED census: not reported	triage	March 1988	waiting time
Toncich ⁵⁸	Australia	before-and-after	single centre, ED census: 42,000 visits per year	multi-faceted	not reported	LOS admitted patients
McAfee ⁸⁰	US	before-and-after	single centre, ED census: 52,555 visits per year	patient order entry	June 2000 to June 2001	overall LOS
Takakuwa ⁹⁰	US	before-and-after	single centre, ED census: 3,037 visits per month	specific (bedside registration)	November 2001 to March 2002	time from disposition to room

APPENDIX 13: Responses of ED Directors across Canada Regarding Interventions Implemented to Alleviate ED Overcrowding

Input	Throughput	Output	System-wide
managing ambulance transfers through dispatch; notify all receiving consultants	float nurse pool	creation of EIP unit to decant admitted patients from ED	ED decongestion plan
no patients booked in ED by non-emergency physicians	establishing fast track clinic as part of ED	one admitted patient from ED sent to hallway of each admitting unit	executive forced to educate whole hospital staff
increasing admissions to group of family physicians who have expressed interest in more in-patient work	nursing directives for fever, pain, abdominal pain, dyspnea, laboratory work drawn before physician encounter based on patient complaints	beds and standby staff available on weekends in short-stay or recovery rooms or other places not normally used on weekends, to absorb ED's overflow	continuing sensitization of hospital administrator and staff
empowering family doctors to consult specialists directly rather than referring to ED for us to re-see	increasing hours of coverage for ED docs (i.e., adding extra shift)	moved intravenous therapy out of ER to medical floor	Minister and Deputy Minister educated about situation of overcrowding
family clinics established with several services to reduce admissions and return visits	pediatric and maternity empty beds converted to adult temporarily	creation of new administrative positions for full-time bed management	formal hospital decongestion plan
use of ambulance as point of care	back-up MD consideration, call if >90 minute wait	code orange internal: in-patients go to ward hallways when certain level of crowding occurs	hospital-wide policy on bed use and bed spacing