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Evidence Check

Variation in paediatric clinical practice

An **Evidence Check** rapid review brokered by the Sax Institute for NSW Kids and Families November 2014

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This report was prepared by:

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March 2015

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Suggested citation:

Hiscock H, Perera P, McLean K, Roberts G. Variation in paediatric clinical practice: An Evidence Check review brokered by the Sax Institute (www.saxinstitute.org.au) for NSW Kids and Families, November 2014.

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Contents

List of abbreviations

ADHD	Attention deficit hyperactivity disorder
ATSI	Aboriginal and Torres Strait Islander peoples
BMI	Body mass index
CAP	Community-acquired pneumonia
CPGs	Clinical practice guidelines
CRP	C-reactive protein
CSF	Cerebrospinal fluid
CT	Computed tomography
CXR	Chest x-rays
DOSA	Day of surgery admissions
ED	Emergency department
ESR	Erythrocyte sedimentation rate
GERD	Gastroesophageal reflux disease
ICU	Intensive care unit
IQR	Interquartile range
IV	Intravenous
LOS	Length of stay
OSA	Obstructive sleep apnoea
NICE	National Institute for Health and Care Excellence
NICU	Neonatal intensive care unit
PHIS	Pediatric Health Information System
PICC	Peripherally inserted central catheter
PICU	Paediatric intensive care unit
PRIS	Pediatric Research in Inpatient Settings
REA	Rapid evidence assessment
SCN	Special care nurseries
T & A	Tonsillectomy & adenoidectomy
UTI	Urinary tract infection
WBC	White blood cell

1 Main messages

Wennberg's framework (2002)[1] is the most common framework used to understand variation in clinical care. It is used in both adult and paediatric settings. It focuses on unwarranted variation i.e. *"variation that cannot be explained by type or severity of illness or by patient preferences"*. It is further categorised as variation in:

- Effective care i.e. when proven, clinically effective care is not used
- Preference-sensitive care i.e. where there are two or more choices for care
- Supply-sensitive care i.e. when variation arises due to availability of healthcare resources such as doctors or pathology services, rather than evidence.

Cheung and Gray (2013)[2] expanded upon Wennberg's 'preference-sensitive care' to include care where the optimal course of action is unclear because evidence is equivocal or based largely on consensus. The latter is true of many common child health conditions such as elective tonsillectomy.

Variation in paediatric clinical care is widespread. It occurs across diseases, clinicians, healthcare settings and geographical regions. Unwarranted variation in care is more common in paediatric units within general hospitals compared with stand-alone children's hospitals.

Training is also associated with unwarranted variation in care. For example, physicians trained in paediatric emergency medicine are less likely to practise unwarranted variation in care compared with physicians trained in general emergency medicine.

The literature primarily identifies associated factors for unwarranted variation in effective care. Common factors include lack of, or awareness of, clinical practice guidelines, lack of high quality evidence to inform practice, physician preference for care, and differences in local and regional primary care systems.

Unwarranted variation in preference-sensitive care is common in severe presentations of a disease, likely reflecting care in the absence of evidence to inform care.

While uptake of clinical practice guidelines is associated with a reduction in unwarranted variation in care, simply producing guidelines does not improve adherence to them.

There is a dearth of Australian research. In order to reduce variation in Australian paediatric care, we need to document what is happening in Australia. Accessing and analysing data from existing national inpatient and emergency department databases will facilitate this. Increased awareness of, and access to, these databases would enable clinicians and researchers to analyse data and publish findings in peer-reviewed journals.

State and national databases for outpatient care are fragmented or non-existent. We need a coordinated, system-wide approach to documenting care in outpatient settings.

Existing datasets collect data on diagnostic and treatment practices and associated costs. Outcomes should be broadened to include patient- and family-centred measures such as quality of life, satisfaction, and mental health and wellbeing.

2 Executive summary

Variation in paediatric clinical care is common. It occurs across diseases, clinicians and healthcare settings and is associated with variation in quality and costs of care.

Wennberg's framework (2002)[1] is the most common framework used to understand variation in clinical care. It focuses on unwarranted variation i.e. *"variation that cannot be explained by type or severity of illness or by patient preferences"*. It is applicable to paediatric care. It categorises unwarranted variation as variation in:

- Effective care i.e. when proven, clinically effective care is not used
- Preference-sensitive care i.e. where there are two or more choices for care
- Supply-sensitive care i.e. when variation arises not due to evidence but due to availability of healthcare resources such as doctors or pathology services.

Cheung and Gray (2013)[2] have expanded upon Wennberg's 'preference-sensitive care', to include care where the optimal course of action is unclear because evidence is equivocal or based largely on consensus. The latter is true of many common child health conditions such as elective tonsillectomy and management of severe asthma.

This review found widespread variation across conditions, clinicians, health settings (inpatient, outpatient and emergency department) and regions. Most studies originated from the US. There is a dearth of Australian data.

This review examined variation in care for 16 common child health conditions across the inpatient, outpatient and emergency department settings, as summarised below.

Inpatient care – 27 studies: Asthma was the most common condition (six studies), followed by tonsillectomy and adenoidectomy (five), bronchiolitis (four), and pneumonia, appendicitis and analgesia/sedation (three each). Twenty-two studies were from the US and only one was from Australia. Secondary data analysis was the most common approach (20 studies), followed by survey (four) and chart review (three). All studies reported unwarranted variation, typically variation in effective care. Some supply-sensitive care variation was noted. Only one study reported warranted variation.

Outpatient care – 20 studies: ADHD and asthma were the most common conditions (four studies each), followed by food allergy, obesity and pneumonia (two each). Fifteen studies were from the US and two were from Australia. Secondary data analysis was the most common approach (nine studies), followed by survey and chart review (six each). All studies reported some form of unwarranted variation in practice, typically variation in effective care. Some supply-sensitive care variation was noted and two reported warranted variation.

Emergency department care – 24 studies: Asthma was the most common condition (seven studies), followed by bronchiolitis and fever (four each), pneumonia (three), and analgesia/sedation and concussion (two each). Fourteen studies were from the US, four from Canada and three from Australia.

Chart review was the most common approach (11 studies), followed by secondary data analysis (eight) and surveys (five). All studies reported some form of unwarranted variation in practice, typically variation in effective care. Some supply-sensitive care variation was noted and three reported warranted variation. Unwarranted variation in effective care occurred in antibiotic use (e.g. use of second- or third-generation versus first-generation antibiotics for simple pneumonia) and asthma and bronchiolitis (e.g. use of chest x-rays).

Across the settings, variation in effective care was the most commonly researched. Reduced variation in effective care was associated with:

- Hospital type i.e. children's versus generalist hospitals
- Clinician training i.e. hospitalists versus non-hospitalists
- Age of clinician i.e. younger clinicians perhaps more likely to be aware of, and adhere to, clinical practice guidelines
- Adherence to clinical practice guidelines
- Electronic order set use. Use of the latter was not associated with a reduction in length of stay or costs.

Variation in preference-sensitive care was the next most commonly researched. This largely occurred due to a lack of good quality evidence as to what care children should receive. This was particularly so for obesity, elective tonsillectomy and adenoidectomy, and ADHD. Disease severity was also associated with variation in preference-sensitive care. For example, care of mild to moderate asthma was generally adherent to clinical practice guidelines while care for severe asthma was not. This likely reflects the lack of good quality evidence for care of more severe presentations and thus clinician deviation from guidelines which are consensus rather than evidence-based.

Few studies reported variation in supply-sensitive care, but this was primarily because it was not measured rather than because it did not occur.

More variation was usually associated with higher healthcare costs and increased length of stay in the inpatient setting.

Patient-related outcomes such as satisfaction and quality of life were not reported. Some study findings can be assumed to be associated with poorer patient outcomes in the short term (e.g. less use of effective analgesia) or long term (e.g. poorer health outcomes due to not regularly measuring BMI). However, such outcomes were neither explicitly measured nor reported.

There were more than 60 factors associated with variation in care, the most common being factors for unwarranted variation in care and proposed, rather than actual, factors. Factors associated with preference-sensitive care were less common, possibly because of the challenges in carrying out research into variation in care when clear, evidence-based treatment recommendations are not yet available.

Common associated factors included:

- Lack of or awareness of, or poorly written, clinical practice guidelines (proposed and actual)
- Lack of high quality evidence to inform practice (proposed)
- Physician preference for care (proposed)
- Differences between local and regional primary care systems e.g. resource (primary care doctors) availability (proposed).

The most reliable data come from secondary data analysis of large, national inpatient and emergency department databases. The most widely researched of these is the Pediatric Health Information System, which encompasses discharge data from inpatient stays in 42 freestanding children's hospitals across the US.

Australia has similar national databases for both inpatient and emergency department care with input from the states and territories. However, Australian clinicians and policy makers rarely meet to review these data and we could find no publications arising from these databases. This is likely because of the lack of awareness of, and ready access to, these data. A key step in reducing unwarranted variation in care would be to make these data readily available to clinicians and researchers for analysis and publication in peer-reviewed journals.

Variation must be accurately measured to reduce variation in paediatric clinical care. Although this review can make cautious recommendations, the authors feel strongly that variation in care delivered to Australian children needs to be more consistently and systematically measured. Furthermore, systems of data linkage should be set up that feed back information into healthcare systems so that interventions to reduce variation can be rigorously evaluated.

State and national databases for outpatient care are fragmented or non-existent. A coordinated, system-wide approach to documenting care in outpatient settings is needed.

Most datasets collect data on diagnostic and treatment practices and their costs, including pathology, radiology, medication and disposal patterns. There is a clear need to broaden these outcomes to include patient- and family-centred measures such as quality of life and mental health and wellbeing.

Attempts to reduce variation in care may need to focus on older doctors and those working in non-teaching or generalist hospitals with paediatric units. Development and uptake of electronic order sets may facilitate reduction in unwarranted variation in effective care. Increased uptake of clinical practice guidelines may also reduce unwarranted variation in care. Ensuring that guidelines are clearly written and easily accessible will likely facilitate uptake.

3 Introduction

Glover's 1938 seminal study highlighted the variation in practice of tonsillectomy in school-aged children across different regions in the UK.[3] Since then, there has been growing interest in variation in practice as it is inevitably associated with variation in both cost and quality of care. However, not everyone views variation as a problem and indeed some variation in care arises because of differences in health needs of a population, cultural expectations and personal values.[2] Thus, some variation is justified and perhaps only variation which has a negative effect on the patient should be minimised.

Different frameworks have been developed to describe variation in care. Wennberg's 2002 framework[1] is among the earliest and most widely used. This framework focuses on unwarranted variation in care i.e. *"variation that cannot be explained by type or severity of illness or by patient preferences*". Wennberg further categorises unwarranted variation as variation in:

- Effective care i.e. when proven clinically effective care is not used
- Preference-sensitive care i.e. where there are two or more choices for care
- Supply-sensitive care i.e. when variation in care arises not due to evidence but due to availability of healthcare resources such as doctors, inpatient beds, or pathology services.

Others have since expanded upon Wennberg's 2002 framework. While a specific paediatric framework does not exist, Cheung and Gray, writing in *Archives Of Disease In Childhood*, extend Wennberg's 'preference-sensitive care' to include care where the optimal course of action is unclear because evidence is equivocal or based largely on consensus.[2] The latter is true of many common child health conditions including elective tonsillectomy.[2] Such preference-sensitive care will often be decided upon by individual doctors, with or without shared decision-making between the doctor and the family.

This rapid review aims to describe variation in clinical paediatric practice for a range of common health conditions across inpatient, outpatient and emergency department settings within developed countries. It also aims to review factors associated with variation – both theoretical and actual.

4 Method

This literature review utilised a rapid evidence assessment (REA) methodology. The REA is a research methodology which uses similar methods and principles to a systematic review but makes concessions to the breadth and depth of the process in order to be completed within a short time frame. Rigorous methods for locating, appraising and synthesising the evidence related to a specific topic are utilised by the REA, however, the methodology places a number of limitations on the search criteria and in how the evidence is assessed. For example, REAs often limit the selection of studies to a specific time frame (e.g. past 10 years) and limit selection of studies to published peer-reviewed, English language studies (therefore excluding unpublished pilot studies, difficult to obtain material and/or non-English language studies). The REA can help inform policy and decision makers more efficiently by synthesising and ranking the evidence in a relatively short space of time, although it is not necessarily as exhaustive as a well-constructed systematic review or meta-analysis.

Defining the research questions

This review focused on three questions:

Question 1: What are the conceptual or theoretical frameworks that are used to understand clinical care variation?

Scope of question 1:

- Include frameworks developed for adult populations, as well as any specific to paediatric populations
- Provide expert opinion on the validity of adult frameworks
- Provide expert opinion on the applicability of adult frameworks to paediatric populations
- Identify any gaps specific to paediatric contexts.

Question 2: What evidence is there for variation (both warranted and unwarranted) in paediatric clinical care?

Scope of question 2:

- Include children aged 0–18 years, emergency department, inpatient- and outpatient-based care, and evidence from Australia and overseas countries with comparably developed health systems
- Include information, where available, about the type of variation observed i.e. warranted/unwarranted variation and subcategories of the latter i.e. effective, preference-sensitive care, supply-sensitive care
- Include outcomes of care, where available, such as suboptimal care, quality of life and readmission rates.

Question 3: Which factors (drivers) have been identified as the underlying causes or associated factors for warranted and unwarranted variation in paediatric clinical care? Specify whether these factors are actual practice of paediatric clinical care or proposed.

Scope of Question 3:

- Identify factors that are common across different studies of paediatric care variation, as well as those that are specific or unique within individual studies
- Include information relevant to important population subgroups, e.g. indigenous, culturally and linguistically diverse, disadvantaged, geographically remote groups.

Search strategy

Two search strategies were developed – search strategy one to address question 1 and search strategy two to address questions 2 and 3.

The following databases were used to identify relevant literature: Ovid MEDLINE, CINAHL (EBSCO), PsycINFO, Cochrane library and PubMed.

Searches were modified in the above databases to account for differences in syntax and thesaurus headings. Searches included terms for both free text and MeSH terms. We used a filter for 'developing countries' to limit the searches to developed countries for questions 2 and 3. The Ovid MEDLINE search strategies are detailed in Appendix 1. Ms Poh Chua, librarian at The Royal Children's Hospital, helped to compile the strategies.

Grey literature

We searched for grey literature using the following sources (September 2014):

- Scanning reference lists of retrieved relevant articles
- Published reviews
- Focused search on Google Scholar (https://scholar.google.com.au)
- Correspondence with experts in the field with reference to paediatric-specific clinical variation frameworks
- Pediatric Research in Inpatient Settings (PRIS) network (www.prisnetwork.org).

Search terms

The search terms specific to the questions that were included in searching the title/s, abstract/s, MeSH terms and keywords lists are listed below.

Table 1: Search terms

	Variation	Setting	Population
Search strategy 1 (MeSH)	Physician's practice patterns/ "Quality of health care"/or "healthcare quality, access, and evaluation"/or "delivery of health care"/ Quality indicators, healthcare/ Practice guidelines as topic Program evaluation/	N/A	No restrictions
Search strategy 1 (free text)	Framework Variation Unwarranted variation Warranted variation Supply sensitive Preference sensitive Preference based Effective care Necessary care	Clinical care Medical care Healthcare Healthcare medical practice Clinical practice	No restrictions
Search strategy 2 (MeSH)	Physician's practice patterns/ Practice guidelines as topic/or guideline adherence/ Healthcare disparities/ Organizational policy/	Exp emergency service, hospital/or exp ambulatory care/	Exp pediatrics/ Limits: "all child (0–18 years)" or "young adult (19–24 years)"
Search strategy 2 (free text)	Variation Unwarranted variation Warranted variation Supply sensitive Preference sensitive Effective care Necessary care	Clinical care Medical care Healthcare Health care Hospital Inpatient Outpatient Emergency Ambulatory	Paediatric

Please note: equivalent MeSH terms were run for PsycINFO, CINAHL and Cochrane.

Paper selection for questions 2 and 3

After conducting searches, studies were evaluated according to the following inclusion and exclusion criteria.

Table 2: Inclusion and exclusion criteria

Included
1. Inpatient, outpatient or emergency department setting
2. Common health conditions with, where possible, two or more publications per condition
3. Age 0–18 years
4. Publications 2000 onwards
5. Full text available
Excluded
1. Non-English language
2. Developing countries
3. Uncommon child health conditions e.g. oesophageal varices
4. Cancer
5. Inpatient psychiatric care
6. Variation in care due to medical insurance status (US)
7. Variation in care due to racial differences (US)
8. Surveys with response rates < 65% (international) or < 40% (Australian)

Information management

Papers identified via filtering and keyword searches were imported into EPPI-Reviewer 4 software. Further refinement was required to ensure that only high quality and relevant publications were included for data extraction. A screening process was adopted to code the eligibility of the papers – the screening form is presented in Appendix 2. All records were screened according to the eligibility criteria and decisions to include or exclude were double-checked by a second reviewer for quality control purposes. Full text versions of all studies identified as meeting eligibility requirements were obtained and uploaded to the software. A qualified reviewer then screened the full text papers and made a decision on whether the paper should be included or excluded based on the research question. Where there was uncertainty, the whole team reviewed the paper and made this decision. Papers meeting the inclusion criteria were subject to data abstraction. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart in Appendices 3 and 4 illustrates the screening process and reference numbers.

Quality of the evidence

Most papers report on databases (e.g. the US Pediatric Health Information System), surveys (e.g. survey of paediatrician practice), or chart reviews. There are no published guidelines as to how to assess the quality of these methodologies. With respect to survey methodology, two papers have suggested a number of variables to assess quality.[4,5] Taking variables common to each, we elected to assess survey quality on the following variables: (i) response rate; (ii) representativeness of survey responders reported (yes/no); (iii) missing data reported (yes/no); (iv) analyses conducted to account for missing data (yes/no); and (v)

validated tool used (yes/no) (see Appendix 8). We defined surveys with a response rate of < 65% as poor quality and excluded such surveys if they were conducted internationally. However, in order to maximise Australian content, we included surveys with a lower response rate i.e. 40% or above. For each survey, we comment on the representativeness or otherwise of their data and the amount of missing data where available (see page 20).

A number of papers analyse data from state-based or national databases of inpatient or emergency department care. These databases often contain large numbers of patients from numerous freestanding and/or general children's hospitals. These databases enable documentation of variation in care between hospitals for multiple conditions and practices (e.g. diagnostic testing, medications used, admission rates, length of stay, patient disposal, costs, etc). However, they too have limitations, including misclassification of diagnosis and disease severity and administrative coding errors. In addition, these databases do not capture factors associated with variation in care.

Chart reviews suffer from limitations similar to those of databases – i.e. misclassification of diagnosis and disease severity – but also suffer from inadequate data capture i.e. they can only report on what the clinician has recorded. This appears to be more of a problem for chart reviews than databases as the latter use data collected for hospital billing purposes, making for more inclusive data recording.

Both chart reviews and secondary data analysis capture actual episodes of care. In contrast, surveys can capture only what clinicians say they do and not necessarily what they actually do.

5 Results

This section discusses the results of the literature pertaining to each question. In order to better understand the variation occurring at a system level as opposed to a disease-specific level, we present our findings for questions 2 and 3 by care setting i.e. inpatient, outpatient and emergency department.

Question 1: What are the conceptual or theoretical frameworks that are used to understand clinical care variation?

We found five theoretical frameworks that have been developed to understand clinical care variation[1,2,6–8] The most widely used framework is Wennberg's and it has been used in both paediatric and adult populations, including the Dartmouth Atlas of Health Care and NHS Atlas of Variation in Healthcare for Children and Young People.[1,9,10]

Cheung and Gray (2013) expand on Wennberg's framework, classifying 'effective' care as 'high value' representing variation that exists despite clinical consensus and evidence unequivocally supporting the care process.[2] They also expand on 'preference-sensitive care' to include care where the optimal course of action is unclear because evidence is equivocal or based largely on consensus. This is common for many child health conditions. They conclude that the difficulty of studying variation in children's healthcare can be due to barriers in data specifically measuring outcomes for children and families.

Goodman's suggested framework delineated unwarranted variation in paediatric care by Wennberg's three categories[7] and included a fourth 'non-utilisation' category pertaining to healthcare capacity, which is largely similar to supply-sensitive care. He highlights the issues facing research into variation in paediatric clinical care, including the lack of population-based data linked to provider and patient location and the need to make such data publicly available. Thus, Wennberg's framework is the most widely used and we believe it is broadly applicable to variation in paediatric practice.

Wennberg's framework conceptualises variation in care as unwarranted variation i.e. "*variation that cannot be explained by type or severity of illness or by patient preferences*". He describes three categories of variation:

- Effective care i.e. when proven, clinically effective care is not used
- Preference-sensitive care i.e. where there are two or more choices for care and that choice should depend on patient preferences
- Supply-sensitive care i.e. when variation in care arises due to availability of healthcare resources.

Question 2: What evidence is there for variation (both warranted and unwarranted) in paediatric clinical care?

We found evidence of widespread variation in both warranted and unwarranted care across conditions, settings, countries and practitioners. We restricted our review to 16 common child health conditions (see Table 3). We included studies of children aged 0–18 years and, where possible, categorised unwarranted variation in care as effective, preference-sensitive care, or supply-sensitive care. We excluded North American studies that focused solely on variation in care due to underlying race (e.g. Latino or African-American) or insurance status, as we deemed such research inapplicable to the Australian context.

All papers discussed variation in care but few discussed outcomes arising from the variation in care. We found no papers reporting on outcomes such as patient satisfaction or quality of life. The following sections detail the variation in care by practice setting and disease/condition.

Table 3: Variation in care

	No. of publications by setting		
Condition	**Inpatient**	**Outpatient**	**ED**
ADHD medication	-	5	1
Allergy	-	2	-
Analgesia/sedation	3	1	2
Antibiotic use/sepsis	3	1	-
Appendicitis	2	-	1
Asthma	6	4	7
Bronchiolitis	4	-	4
Concussion/traumatic brain injury	2	-	2
Diabetes	1	1	1
Fever/febrile infants	-	1	4
Obesity	-	2	-
Otitis media/grommets	-	1	-
Pneumonia	3	2	3
Status epilepticus	-	-	1
Tonsillectomy and adenoidectomy	5	1	-
Urinary tract infections	-	-	2
TOTAL	29	21	28

Inpatient care variation

Twenty-seven studies examined variation in inpatient care, with the most common conditions being asthma (six studies), tonsillectomy and/or adenoidectomy (five), bronchiolitis (four), and pneumonia, appendicitis, and analgesia and sedation (three each). Twenty-two studies were from the US and one was from Australia. Secondary data analysis was the most common approach (20 studies), followed by survey (four) and chart review (three).

All 27 studies reported some form of unwarranted variation in practice. This was mostly categorised as variation in effective care, although some supply-sensitive care variation was also noted. One study also reported warranted variation based on disease severity.[11]

Variation in effective care was common even for conditions where the evidence for management is strong. Most variation concerned inappropriate use of investigations and/or overprescription of inappropriate treatments. For example, use of chest x-rays and antibiotics was common for bronchiolitis, as were blood cultures, CRP and ESR for simple pneumonia. Increased number of investigations was associated with longer length of stay and costs. Some variation concerned underuse of treatments e.g. sucrose or breastfeeding to alleviate pain.[12] Hospitalists and staff working in children's hospitals (as opposed to general hospitals) were less likely to practise care which deviated from guidelines. Use of electronic order sets was associated with reduced variation in care. Rates of tonsillectomy continue to vary by region in the US, Canada and Europe, with more tonsillectomies performed in wealthier and rural areas in Canada.

Variation increased when disease severity increased (e.g. asthma, perforated appendicitis), likely reflecting the lack of good quality evidence to inform best practice in severe disease.

Appendix 5 details the 27 studies including health condition, key findings and type of unwarranted variation in inpatient care, where relevant.

Outpatient care variation

Twenty studies examined variation in outpatient care, with the most common conditions being ADHD (four studies), asthma (four), food allergy (two), obesity (two) and pneumonia (two). Fifteen studies were from the US, two were from Australia, two were from the UK and one was from Europe. Secondary data analysis was the most common approach (nine studies), followed by survey and chart review (six each). One Australian study used survey, chart review and qualitative data.[13]

Nine studies examined variation at a country level, three at a regional level, six at multiple hospital sites and one at a single site. One study observed variation across five Nordic countries.[14]

All studies reported some form of unwarranted variation in practice. This was mostly variation in effective care (13 studies). In contrast to inpatient care, variation in effective outpatient care often concerned under-management. For example, in well child visits, only 0.5% of children had their BMI recorded and there was wide variation in the recorded diagnosis of obesity in these children.[15] Use of an otoscope or tympanometry to diagnose otitis media in Aboriginal children was also underperformed.[16] Over-management did occur (e.g. chest x-rays in pneumonia, excessive screening tests in diabetes) and supply-sensitive care variation was noted in three studies.[14,17,18] For example, in Bruckner et al. (2012), the rise in ADHD medical prescriptions was attributed to supply-side healthcare factors.[17] Preference-sensitive care was also common (11 studies), especially in the management of ADHD e.g. use of psychotherapy.[19,20] Two studies also

reported warranted variation based on disease severity.[11,21] Similar to inpatient care, a reduction in variation in effective care was noted in junior versus senior doctors and in teaching versus non-teaching hospitals.

Appendix 6 details the 20 studies including health condition, key findings and type of unwarranted variation in outpatient care, where relevant.

Emergency department care variation

Twenty-four studies examined variation in emergency department care, with the most common conditions being asthma (seven), bronchiolitis and fever/febrile infants (four each), pneumonia (three), and analgesia/sedation, concussion/traumatic brain injury and urinary tract infections (two each). Fourteen studies were from the US, four were from Canada and three were from Australia. Chart review was the most common approach (11 studies), followed by secondary data analysis (eight) and surveys (five).

All 24 studies reported some form of unwarranted variation in practice. This was mostly categorised as variation in effective care, although some supply-sensitive care variation was also noted. Similar to inpatient care, variation in effective care often concerned over-management e.g. use of chest x-rays and blood tests in asthma, use of chest x-rays, antibiotics and beta agonists in bronchiolitis, and use of chest x-rays in fever and upper respiratory tract infections. Variation in effective care relating to under-management also occurred, e.g. inadequate use of corticosteroids in moderate to severe asthma, lack of spacer use in asthma, and lack of written advice for parents following concussion in their child. Variation in preference-sensitive care occurred in 10 studies and often centred around lack of evidence for management of more severe illness e.g. severe asthma, pneumonia and status epilepticus.

Three studies (11%) also reported warranted variation, again based on disease severity.[22–24]

A reduction in variation in effective care was noted in paediatric emergency medicine versus general emergency medicine trained doctors.

Appendix 7 details the 24 studies including health condition, key findings and type of unwarranted variation in emergency department care, where relevant.

Quality assessment of surveys

Fourteen of the included papers were surveys (three inpatient, six outpatient, five emergency department). The two lowest response rates were reported in Morawetz et al. (2014) (43%) and Gunasekera et al. (2009) (55 per cent).[16,18] Both of these studies were conducted in Australia. Only one study with a survey design presented data on non-responders.[18] The remaining 13 studies had missing data on non-responders which was not adequately addressed, and only three of these studies acknowledged response bias as a limitation. For all the surveys, either the sample population was not representative of the background population or it was unclear whether or not this was the case. None of the studies used validated questionnaires, although some were piloted or reviewed prior to being implemented. Appendix 8 details the quality assessment of the surveys.

Question 3

Which factors have been identified as the underlying causes or associated factors for warranted and unwarranted variation in paediatric clinical care? Specify whether these factors have been identified in the actual practice of paediatric clinical care or if they are proposed at a theoretical level.

Many papers identified factors associated with variation in care (see Table 4). More reported on proposed factors rather than actual factors (see Table 5, pages 22-28).

Table 4: Factors associated with variation in care

Setting	Papers proposing associated factors	Papers reporting actual and proposed associated factors	Papers reporting actual associated factors	Total no. of papers reporting associated factors
Inpatient care	13	3	2	18/27
Outpatient care	9	6	2	17/20
ED care	11	4	2	17/24

Associated factors for variation in effective care were the most commonly reported and include adherence to clinical practice guidelines, the setting in which the child is seen, the specialist training of the clinician, and the seniority of the clinician. The most commonly reported associated factor was lack of clinical practice guidelines or varying degrees of clinical practice guideline adherence (proposed and actual), which was reported in 16 papers across all settings for 14 conditions (predominantly asthma and pneumonia). Less variation occurs in specialist children's hospitals compared with general hospitals, the practice of clinicians with specialist paediatric training compared with generalists, and the practice of more junior doctors compared with more senior doctors. These factors are likely to be modifiable with intervention as (a) target groups for intervention can be identified and (b) evidence-based recommendations for care are available.

Associated factors for variation in preference-sensitive care are more challenging to identify and modify. The most commonly reported associated factor was a lack of high quality evidence to inform guidelines (proposed) seen in inpatient and emergency department care for nine of the conditions (predominantly severe asthma and concussion/traumatic brain injury), leading to variation in preference-sensitive care (eight papers). However, standardised care that is defined by expert consensus, delivered consistently and evaluated over time may provide a way forward. Caution must be taken to ensure that development of this care is done in consultation with the providers who will use it and championed by local leaders. Merely producing new guidelines does not ensure increased uptake of effective or preference-sensitive care.

Associated factors for variation in supply-sensitive care were not explicitly identified in the existing literature, although inequalities in availability and access to care clearly exist. These inequalities are likely to be best addressed at a health policy level, using population-level data to decide on priorities.

No studies reported on associated factors for variation in care for culturally and linguistically diverse or disadvantaged groups. One study reported on variation in care for Aboriginal children with an increased use of antibiotics for otitis media with/without effusion.[16] This variation in care may be warranted given that Aboriginal children are more likely than non-Aboriginal children to have bacterial ear infections.

Table 5: Summary of associated factors for variation in care

No.	Associated factor (actual vs proposed)	Setting (IP/OP/ED)	Paper	Number of articles per condition
1	Varying degrees of patient adherence to medication (proposed)	IP/OP/ED	Adams et al. (2001)[25] Kenyon et al. (2014)[26]	Asthma (2)
2	Less frequent physician visits (proposed)	IP/OP/ED	Adams et al. (2001)[25]	Asthma (1)
3	External influences e.g. adolescents not being allowed to carry medication on their person while at school (proposed)	IP/OP/ED	Adams et al. (2001)[25]	Asthma (1)
4	Increased testing (proposed)	IP	Brogan et al. (2012)[27]	Pneumonia (1)
5	Hospital variation in efficiency of discharge process (proposed)	IP	Brogan et al. (2012)[27]	Pneumonia (1)
6	Variation in outpatient care or follow-up care (proposed and actual)	IP/ED	Brogan et al. (2012)[27] Mahant et al. (2014)[28] Kool et al. (2014)[29]	Pneumonia (1) Tonsillectomy & adenoidectomy (1) Concussion/traumatic brain injury (1)
7	Inadequate/variation education of family members/inadequate patient education materials (proposed & actual)	IP/OP	Brogan et al. (2012)[27] Rhodes et al. (2006)[30] Mahant et al. (2014)[28]	Pneumonia (1) Diabetes (1) Tonsillectomy & adenoidectomy (1)
8	Informal, social communication fostered attitudes of physicians (actual)	IP	Chisolm et al. (2006)[31]	Asthma (1)
9	High quality order sets with saved time (actual)	IP	Chisolm et al. (2006)[31]	Asthma (1)
10	Lack of use of evidence-based practices/lack of familiarity with recommended practices/lack of standardised clinical practice/unclear recommendations (proposed & actual)	IP OP/ED	Chisolm et al. (2006)[31] Gupta et al. (2014)[13] Parr et al. (2006)[32] Rhodes et al. (2006)[30] Babl et al. (2009)[33]	Asthma (2) Food allergy (1) Diabetes (1) Status epilepticus (1)
11	Ease of use of order sets (actual)	IP	Chisolm et al. (2006)[31]	Asthma (1)
12	Degree of physician's awareness of clinical practice guidelines (actual & proposed)	IP	Chisolm et al. (2006)[31] Foster et al. (2013)[12]	Asthma (1) Analgesia & sedation (1)

No.	Associated factor (actual vs proposed)	Setting (IP/OP/ED)	Paper	Number of articles per condition
13	Perceived quality of order set (actual & proposed)	IP/OP	Chisolm et al. (2006)[31] McAlearney et al. (2006)[34]	Asthma (1) Pneumonia (1) Post-appendectomy care (1)
14	Continuous education on order sets: multimodal, formal and informal (actual)	IP	Chisolm et al. 2006)[31]	Asthma (1)
15	Clinical ownership of order sets with commitment to standardisation and access to high quality evidence (actual & proposed)	IP/OP	Chisolm et al. (2006)[31] McAlearney et al. (2006)[34]	Asthma (1) Pneumonia (1) Post-appendectomy care (1)
16	Lack of evidence base/high quality clinical data or conflicting evidence (proposed)	IP/ED	Ennis et al. (2013)[35] Landrigan et al. (2008)[36] Rangel et al. (2011)[37] Rice-Townsend et al. (2014)[38] Kool et al. (2014)[29] Plint et al. (2004)[22] Uspal et al. (2013)[24] Widger et al. (2009)[39]	Concussion/traumatic brain injury (2) Asthma (2) Bronchiolitis (1) Gastroenteritis (1) GERD (1) Antibiotics use (1) Appendicitis (1) Bronchiolitis (1) Analgesia & sedation (1)
17	Clinical/diagnostic uncertainty (proposed)	IP	Fedeli et al. (2009)[40] Rangel et al. (2011)[37]	Tonsillectomy & adenoidectomy (1) Antibiotics use (1)
18	Clinician's general propensity/perception/preconceived views (proposed)	IP/OP	Fedeli et al. (2009)[40] Patrick et al. (2012)[41] Mabry et al. (2005)[42]	Tonsillectomy & adenoidectomy (1) Neonatal sepsis (1) Obesity (1)
19	Different patterns of care and diagnosis (proposed)	IP	Fedeli et al. (2009)[40]	Tonsillectomy & adenoidectomy (1)

No.	Associated factor (actual vs proposed)	Setting (IP/OP/ED)	Paper	Number of articles per condition
20	Type of setting (NICU vs SCN or postnatal ward – actual/teaching vs non-teaching hospitals – proposed/hospitalist vs non-hospitalist – proposed/paediatric vs generalist hospitals – proposed/non-paediatric clinic – actual)	IP/OP/ED	Foster et al. (2013)[12] Gaur et al. (2005)[43] McCulloh et al. (2012)[44] Rice-Townsend et al. (2014)[38]	Analgesia & sedation (1) Antibiotics use (1) Bronchiolitis (1) Appendicitis (1)
21	No. of births/annum and higher level care units (actual)	IP	Foster et al. (2013)[12]	Analgesia & sedation (1)
22	Lack of clinical practice guidelines or varying degrees of clinical practice guideline adherence/application/acceptability/appropriateness awareness/clarity/familiarity (proposed & actual)	IP/OP/ED	Brogan et al. (2012)[27] Kenyon et al. (2014)[26] Langhan et al. (2012)[45] Patrick et al. (2012)[41] Suleman et al. (2010)[46] Dorsey et al. (2005)[15] Gaur et al. (2005)[43] Gunasekera et al. (2009)[16] Gupta et al. (2014)[13] Mahmood et al. (2007)[47] Zoëga et al. (2011)[14] Babl et al. (2008)[48] Bourgeois et al. (2014)[49] Goldman et al. (2009)[50] Isaacman et al. (2001)[51] Widger et al. (2009)[39]	Asthma (4) Analgesia & sedation (1) Neonatal sepsis (1) Tonsillectomy & adenoidectomy (1) Obesity (1) Antibiotics use (1) Otitis media (1) Food allergy (1) Pneumonia (3) ADHD (1) Bronchiolitis (1) UTI (1) Concussion/traumatic brain injury (1) Fever (2)
23	Non-medical factors: accessibility to different care settings/cost of transportation (proposed & actual)	IP/OP	Kenyon et al. (2014)[26] To et al. (2010)[52] Rhodes et al. (2006)[30]	Asthma (1) Appendicitis (1) Diabetes (1)
24	Variation in surgical technique (proposed)	IP	Mahant et al. (2014)[28]	Tonsillectomy & adenoidectomy (1)
25	Variation in pain management (proposed)	IP	Mahant et al. (2014)[28]	Tonsillectomy & adenoidectomy (1)

No.	Associated factor (actual vs proposed)	Setting (IP/OP/ED)	Paper	Number of articles per condition
26	Case complexity (proposed)	IP/OP	McAlearney et al. (2006)[34]	Asthma (1) Pneumonia (1) Post-appendectomy care (1)
27	Increased accessibility to respond to acute changes in patient condition (proposed)	IP	McCulloh et al. (2012)[44]	Bronchiolitis (1)
28	Increased pressure on clinicians/clinician frustration (proposed)	IP/ED	Rangel et al. (2011)[37] Plint et al. (2004)[22]	Antibiotics use (1) Bronchiolitis (1)
29	Varying degrees of clinician's experience/competency (proposed)	IP/OP/ED	Rice-Townsend et al. (2014)[38] Hoagwood et al. (2000)[19] Parr et al. (2006)[32]	Appendicitis (1) ADHD (1) Asthma (1)
30	Patient/family preferences (proposed)	IP/OP/ED	Rice-Townsend et al. (2014)[38] Bhatara et al. (2007)[20] Gellad et al. (2014)[53] Uspal et al. (2013)[24]	Appendicitis (1) ADHD (2) Analgesia & sedation (1)
31	Patient's characteristics e.g. clinical & non-clinical (SES; ethnicity; children living with 2 parents; location; payment option), condition, severity, comorbidity profile & gender (proposed and actual)	IP/OP/ED	Rice-Townsend et al. (2014)[38] Tieder et al. (2013)[54] Bergman et al. (2006)[21] Dorsey et al. (2005)[15] Gunasekera et al. (2009)[16] Hoagwood et al. (2000)[19]	Appendicitis (1) Diabetes (1) Febrile infants (1) Obesity (1) Otitis media (1) ADHD (1)
32	Physician's preferences/perspectives (proposed)	IP/OP/ED	Suleman et al. (2010)[46] Bhatara et al. (2007)[20]	Tonsillectomy & adenoidectomy (1) ADHD (3)

No.	Associated factor (actual vs proposed)	Setting (IP/OP/ED)	Paper	Number of articles per condition
			Gellad et al. (2014)[53] Zoëga et al. (2011)[14] Isaacman et al. (2001)[51] Ochoa et al. (2012)[55]	Fever (1) Bronchiolitis (1)
33	Parental enthusiasm (proposed)	IP	Suleman et al. (2010)[46]	Tonsillectomy & adenoidectomy (1)
34	Parental smoking (proposed)	IP	Suleman et al. (2010)[46]	Tonsillectomy & adenoidectomy (1)
35	Supply-side healthcare factors (e.g. bed utilisation; concentration of total physicians; lack of equipment; institutional restraints and lack of resources) (actual & proposed)	IP/OP	Tieder et al. (2013)[54] Bruckner et al. (2012)[17] Gunasekera et al. (2009)[16] Ennis et al. (2013)[35]	Diabetes (1) ADHD (1) Otitis media (1) Concussion/traumatic brain injury (1)
36	Inadequate adjustment for differences in hospitals' rates of readmission (proposed)	IP	Tieder et al (2013)[54]	Diabetes (1)
37	Timely access and use of ultrasound (actual)	IP	To et al (2010)[52]	Appendicitis (1)
38	Availability of surgeons (actual)	IP	To et al (2010)[52]	Appendicitis (1)
39	Practice site fixed effects (actual)	OP	Bergman et al (2006)[21]	Febrile infants (1)
40	Provider and practice characteristics/physician practice patterns (actual & proposed)	OP/ED	Bergman et al. (2006)[21] Bourgeois et al. (2014)[49]	Febrile infants (1) Asthma (1) Bronchiolitis (1) Pneumonia (1) Urinary tract infection (1) Concussion/traumatic brain injury (1)
41	Better insurance cost coverage (proposed)	OP/ED	Bhatara et al. (2007)[20]	ADHD (1)
42	Technical innovation of new drug formulations (proposed)	OP	Bruckner et al. (2012)[17]	ADHD (1)
43	Lack of standardised and systematic treatment strategies that incorporate behaviour modification techniques (proposed)	OP	Dorsey et al. (2005)[15]	Obesity (1)

No.	Associated factor (actual vs proposed)	Setting (IP/OP/ED)	Paper	Number of articles per condition
44	Level of training (proposed & actual)	IP/OP/ED	Gaur et al. (2005)[43] Goldman et al. (2009)[50] Hoagwood et al. (2000)[19] Patrick et al. (2012)[41] Zoëga et al. (2011)[14] Stanley et al. (2007)[56] Uspal et al. (2013)[24]	Antibiotics use (1) Fever (1) ADHD (2) Neonatal sepsis (1) Asthma (1) Analgesia & sedation (1)
45	Access to recent literature (proposed)	OP	Gaur et al. (2005)[43]	Antibiotics use (1)
46	Diagnosis of bronchitis (actual)	OP	Gaur et al. (2005)[43]	Antibiotics use (1)
47	Patient being seen before the publication of clinical practice guidelines (actual)	OP	Gaur et al. (2005)[43]	Antibiotics use (1)
48	Varying degrees of documentation/documentation errors (proposed & actual)	OP/ED	Gupta et al. (2014)[13] Mabry et al. (2005)[42] Kelly et al. (2003)[57]	Food allergy (1) Obesity (1) Asthma (1)
49	Lack of clarity of the paediatrician role (proposed)	OP	Gupta et al. (2014)[13]	Food allergy (1)
50	Getting MH counselling; not getting psychotherapy (actual)	OP	Hoagwood et al. (2000)[19]	ADHD (1)
51	Lack/more time (proposed)	OP	Hoagwood et al. (2000)[19] Rhodes et al. (2006)[30]	ADHD (1) Diabetes (1)
52	Psychotherapy used as alternative to stimulants (proposed)	OP	Hoagwood et al. (2000)[19]	ADHD (1)
53	Patient/family perception (actual)	OP	Rhodes et al. (2006)[30]	Diabetes (1)
54	Anticipated noncompliance with screening (actual)	OP	Rhodes et al. (2006)[30]	Diabetes (1)

No.	Associated factor (actual vs proposed)	Setting (IP/OP/ED)	Paper	Number of articles per condition
55	Drug accessibility (proposed)	OP	Zoëga et al. (2011)[14]	ADHD (1)
56	Availability of treatment alternatives (proposed)	OP	Zoëga et al. (2011)[14]	ADHD (1)
57	Differences in local and regional primary care systems e.g. resource availability (proposed)	ED	Bourgeois et al. (2014)[49]	Asthma (1) Bronchiolitis (1) Concussion/traumatic brain injury (1) Pneumonia (1) Urinary tract infection (1)
58	Physicians following adult-based care (proposed)	ED	Isaacman et al. (2001)[51]	Fever (1)
59	Under-classification of severity (proposed)	ED	Kelly et al. (2003)[57]	Asthma (1)
60	More pressing priorities (actual)	ED	Kool et al. (2014)[29]	Concussion/traumatic brain injury (1)
61	Use of inhaled bronchodilators in mild cases (actual)	ED	Ochoa et al. (2012)[55]	Bronchiolitis (1)
62	Independent predictors of comprehensive therapy: daytime presentation and 'intensive stabilization' (actual)	ED	Schuh et al. (2012)[58]	Asthma (1)
63	Clinician's reliance on primary care providers to prescribe drugs at follow-up (proposed)	ED	Schuh et al. (2012)[58]	Asthma (1)

IP = inpatient; OP = outpatient; ED = emergency department; MH = mental health; GERD = gastroesophageal reflux disease.

The appendices below include tables detailing associated factors for variation in care by setting:

- Associated factors for variation in inpatient care (Appendix 9)
- Associated factors for variation in outpatient care (Appendix 10)
- Associated factors for variation in emergency department care (Appendix 11).

Grey literature

Some international research networks and governments have explored variation in paediatric clinical care. Without exception, all have noted wide variation in care across settings, diseases and practitioners, echoing the findings of the published literature. However, none have reported on factors associated with variation in care – either at a theoretical or actual level. Below is a list of major international sources together with a summary of key findings.

1. The Dartmouth Atlas of Health Care documents the variations in the use and distribution of medical resources in the US healthcare system using Medicare data.[9] Data on children's healthcare examine small area variations in northern New England, showing the patterns of care for ambulatory physician services, hospitalisation, common surgeries, imaging and outpatient prescription fills by hospital service areas and paediatric surgical areas. The findings show that although there are many examples of excellent care, there are marked variations in all patterns of care across the region.

2. The NHS Atlas of Variation in Healthcare for Children and Young People shows the magnitude in unwarranted variation in relation to child health services provided by the National Health Service in the UK.[10] Variations were found in the following areas:

Inpatient admissions > 3 days' duration in children per 100,000 population aged 0–17 years for mental health disorders:

- Emergency admissions for children with epilepsy per 100,000 population aged 0–17 years
- Mean length of emergency stay for epilepsy aged 0–17 years
- Emergency admissions for asthma per 100,000 population aged 0–17 years
- Admissions for bronchiolitis per 100,000 population aged under 2 years
- Mean length of stay for bronchiolitis in children aged under 2 years
- Emergency department attendances per 1000 population aged under 5 years.

The report highlighted the need to improve the quality and accessibility of data collection systems to be able to tackle unwarranted variations in healthcare and thus deliver the best possible health outcomes for children and young people.

3. Pediatric Health Information System (PHIS). The PHIS database is a comprehensive paediatric database operated by the Children's Hospital Association containing administrative and financial details for more than six million patient cases from 44 leading US children's hospitals. PHIS+ contains clinical data such as laboratory, microbiology and radiology results obtained in multiple sites of care (inpatient, outpatient, emergency department and day surgery). Working in conjunction with the Pediatric Research in Inpatient

Settings network, PHIS+ is currently conducting the Prioritization Project. Using existing detailed administrative data from 42 US children's hospitals in the PHIS network as well as over 600 hospitals in the Premier Perspectives database, the project will identify paediatric hospital conditions that are prevalent and cumulatively expensive to the healthcare system, and that exhibit high degrees of variation in resource utilisation. For a limited number of diagnoses, the Prioritization Project team will also seek explanations for extreme variation, both in terms of resource categories that may be driving variation (e.g. radiology, laboratory, or length of stay costs), and organisational factors associated with more cost-effective care (e.g. use of, and adherence to, clinical practice guidelines).

4. Children's Healthcare Australasia Benchmarking Program in paediatric care provides a service to members which allows them to benchmark their service against a dashboard suite of indicators and/or activity and costing data for emergency department and inpatient settings. It allows them to compare their service with similar sized participating services in Australia and New Zealand to help identify areas where their service is doing well and areas needing improvement. However, the data are not readily available or published (except for an annual de-identified report), so we are unable to present any key findings. Report indicators include:

- Elective surgery waiting times
- Emergency care – admission
- Waiting times, access block
- Average length of stay for selected conditions
- Asthma management
- Incident monitoring
- Relative workload types
- Bed occupancy
- Human resource management – staffing costs, staff turnover
- Mental health
- Infection control.

5. The Health Roundtable is comprised of 87 health service organisations with a total of 147 facilities across Australia and New Zealand. It provides members with data for comparative analysis between similar departments on inpatient care (length of stay, readmission and DOSA rates and complications of care), emergency department care (percentage discharged within four hours, hourly presentation patterns and monthly volume trends) and in-hospital standardised mortality rate. They have recently formed a paediatric benchmarking group and produce tailored 'paediatric only' six-monthly reports extracting data from the inpatient episode collection, highlighting trends and differences in performance. However, outpatient data is not collected and similar to the Children's Healthcare Australasia Benchmarking Program, the data are not readily available or published.

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7 Appendices

Appendix 1: Information retrieval

Table 1: Question 1 search strategy for Ovid MEDLINE (1996 to present): accessed on 02/09/14

Step	Search terms	No. of records
S1	(variance or variation* or unwarranted varia* or warranted varia* or supply sensitive or supply-sensitive or preference-sensitive or preference sensitive or preference-based or preference based or effective care or necessary care).ab,kw,ti.	381,489
S2	((clinical adj3 care) or (medical adj3 care) or healthcare or health care or medical practice or clinical practice).ab,kw,ti.	347,406
S3	"framework*".ab,kw,ti.	100,167
S4	1 and 2 and 3	456
S5	Physician's practice patterns/	38,292
S6	"quality of health care"/or "health care quality, access, and evaluation"/or "delivery of healthcare"/	78,043
S7	Quality indicators, healthcare/	10,525
S8	Program evaluation/	40,746
S9	Practice guidelines as topic/	80,032
S10	5 or 6 or 7	122,825
S11	3 or 8 or 9	216,656
S12	1 and 10 and 11	904
S13	2 and 12	367
S14	4 or 13	733

Table 2: Questions 2 & 3 search strategy for Ovid MEDLINE (1996 to present): accessed on 02/09/14

Step	Search terms	No. of records
S1	Physician's practice patterns/	38,098
S2	(variance or variation).mp.	500,300
S3	Practice guidelines as topic/or guideline adherence/	91,845
S5	exp emergency service, hospital/or exp ambulatory care/	61,556
S6	(hospital* or inpatient* or outpatient* or emergency or ambulatory).mp.	839,969
S7	1 and (2 or 3 or 4) and (5 or 6)	2776
S8	exp general practice/	37,116

Step	Search terms	No. of records
S9	Primary health care/	41,184
S10	*Physician's practice patterns/ and (2 or 3 or 4)	5507
S11	10 not (8 or 9)	4535
S12	organizational policy/	9196
S13	(clinician* or physician*).mp.	361,980
S14	((institution* or organisation* or organization*) adj2 (policy or policies or guideline*)).mp.	11,680
S15	(comply or compliance or adher*).mp.	171,403
S16	13 and (12 or 14) and 15	178
S17	(unwarranted varia* or warranted varia* or supply sensitive or preference sensitive or effective care or necessary care).mp.	1583
S18	(clinical care or (medical adj3 care) or healthcare or health care).mp.	498,154
S19	(17 and (18 or 5 or 6)) not (8 or 9)	986
S20	7 or 11 or 16 or 19	6875
S21	limit 20 to ("all child (0 to 18 years)" or "young adult (19 to 24 years)")	1312
S22	exp pediatrics/or (pediatric* or paediatric* or young adult*).mp.	574,711
S23	20 and 22	890
S24	21 or 23	1406
S25	developing countries/	34,838
S26	(developing countr$ or third world or underdeveloped countr$ or under developed countr$).mp.	55,371
S27	exp africa/	124,851
S28	americas/or exp caribbean region/or exp central america/or latin america/or mexico/or exp south america/	113,382
S29	europe/or exp europe, eastern/or exp transcaucasia/	132,781
S30	antarctic regions/or exp atlantic islands/or exp indian ocean islands/or exp pacific islands/	36,477
S31	New Guinea/	279
S32	asia/or exp asia, central/or asia, southeastern/or borneo/or cambodia/or east timor/or indonesia/or laos/or malaysia/or mekong valley/or myanmar/or philippines/or thailand/or vietnam/or asia, western/or bangladesh/or bhutan/or india/or middle east/or afghanistan/or iran/or iraq/or jordan/or lebanon/or oman/or saudi arabia/or syria/or turkey/or yemen/or nepal/or pakistan/or sri lanka/or far east/or china/or tibet/or exp korea/or mongolia/	255,887
S33	(Afghanistan or Albania or Algeria or Angola or Antigua or Argentina or Armenia or Azerbaijan or Bangladesh or Barbados or Barbuda or Belarus or Belize or Bhutan or Bolivia or Bosnia or Botswana or Brazil or Bulgaria or Burkina Faso or Burundi or Cambodia or Cameroon or Central African Republic or Chad or Chile or Colombia or Comoros or Congo or Costa Rica or Croatia or Cuba or Czech* or Congo or Djibouti or Dominica or Dominican or East	2,292,057

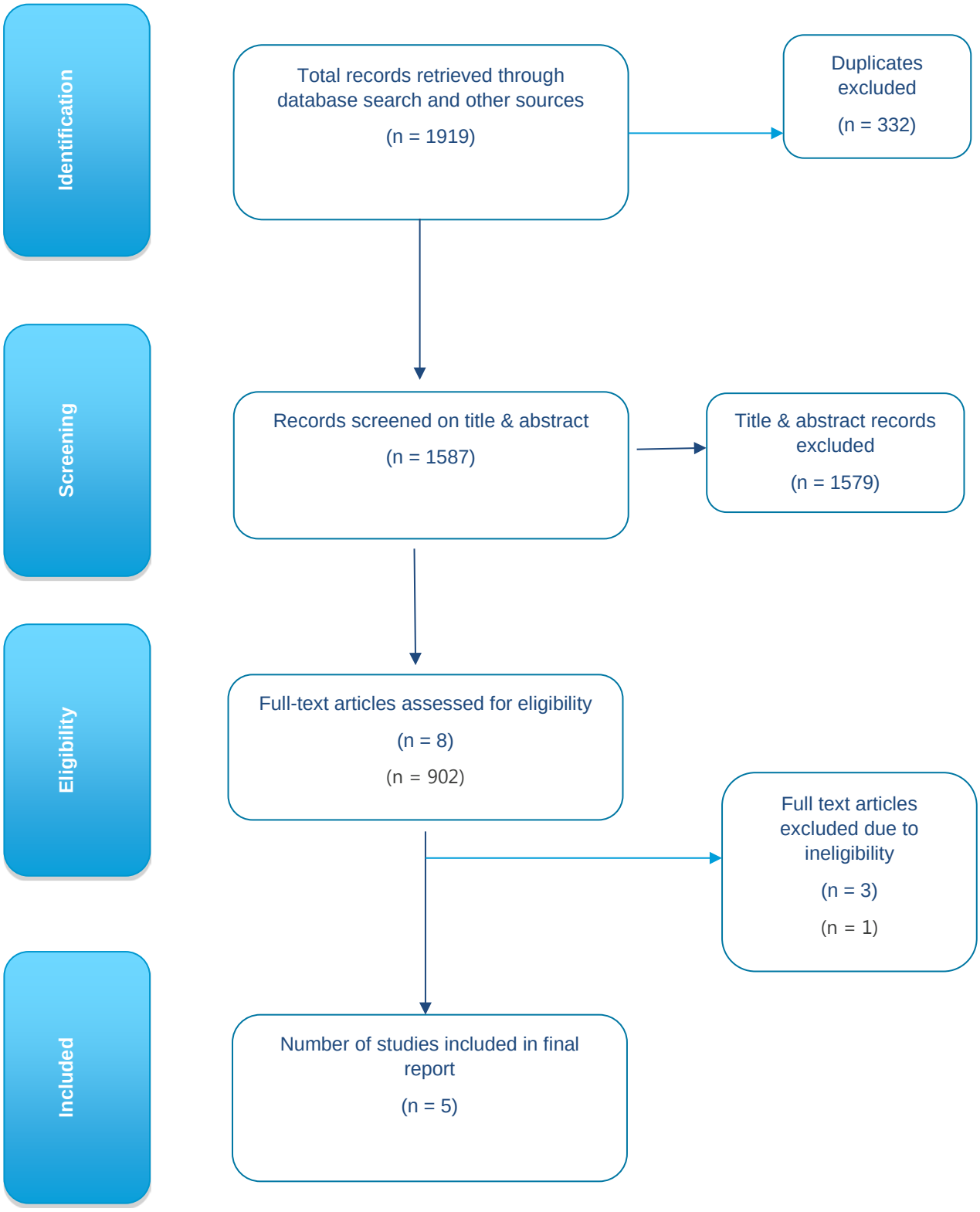
Step	Search terms	No. of records
	Timor or Ecuador or Egypt or El Salvador or Equatorial Guinea or Eritrea or Estonia or Ethiopia or Fiji or Gabon or Gambia or Ghana or Grenada or Guatemala or Guinea-Bissau or Guyana or Haiti or Honduras or Hungary or India or Indonesia or Iran or Iraq or Ivory Coast or Jamaica or Jordan or Kazakhstan or Kenya or Kiribati or Kyrgyzstan or Laos or Latvia or Lebanon or Lesotho or Liberia or Libya or Lithuania or Madagascar or Malawi or Malaysia or Maldives or Mali or Marshall Islands or Mauritania or Mauritius or Mexico or Micronesia or Moldova or Mongolia or Montenegro or Morocco or Mozambique or Myanmar or Namibia or Nepal or New Guinea or Nicaragua or Niger or Nigeria or Korea or Oman or Pakistan or Palau or Panama or Papua New Guinea or Paraguay or Benin or China or Peru or Philippines or Poland or Cape Verde or Georgia or Kosovo or Macedonia or Yemen or Romania or Russia or Rwanda or Saint Kitts or Saint Vincent or Saint Lucia or Sao Tome Principe or Saudi Arabia or Senegal or Serbia or Seychelles or Sierra Leone or Slovak* or South Africa or Solomon Islands or Somalia or Sri Lanka or Sri-Lanka or Sudan or Suriname or Swaziland or Syria or Tajikistan or Tanzania or Thailand or Togo or Tonga or Trinidad or Tobago or Tunisia or Turkey or Turkmenistan or Uganda or Ukraine or Uruguay or Uzbekistan or Vanuatu or Venezuela or Vietnam or Samoa or Zambia or Zimbabwe).af.	
S34	25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33	2,410,286
S35	24 and 34	252
S36	24 not 35	1154
S37	limit 36 to (english language and yr="2000-Current")	963

Appendix 2: Screening form

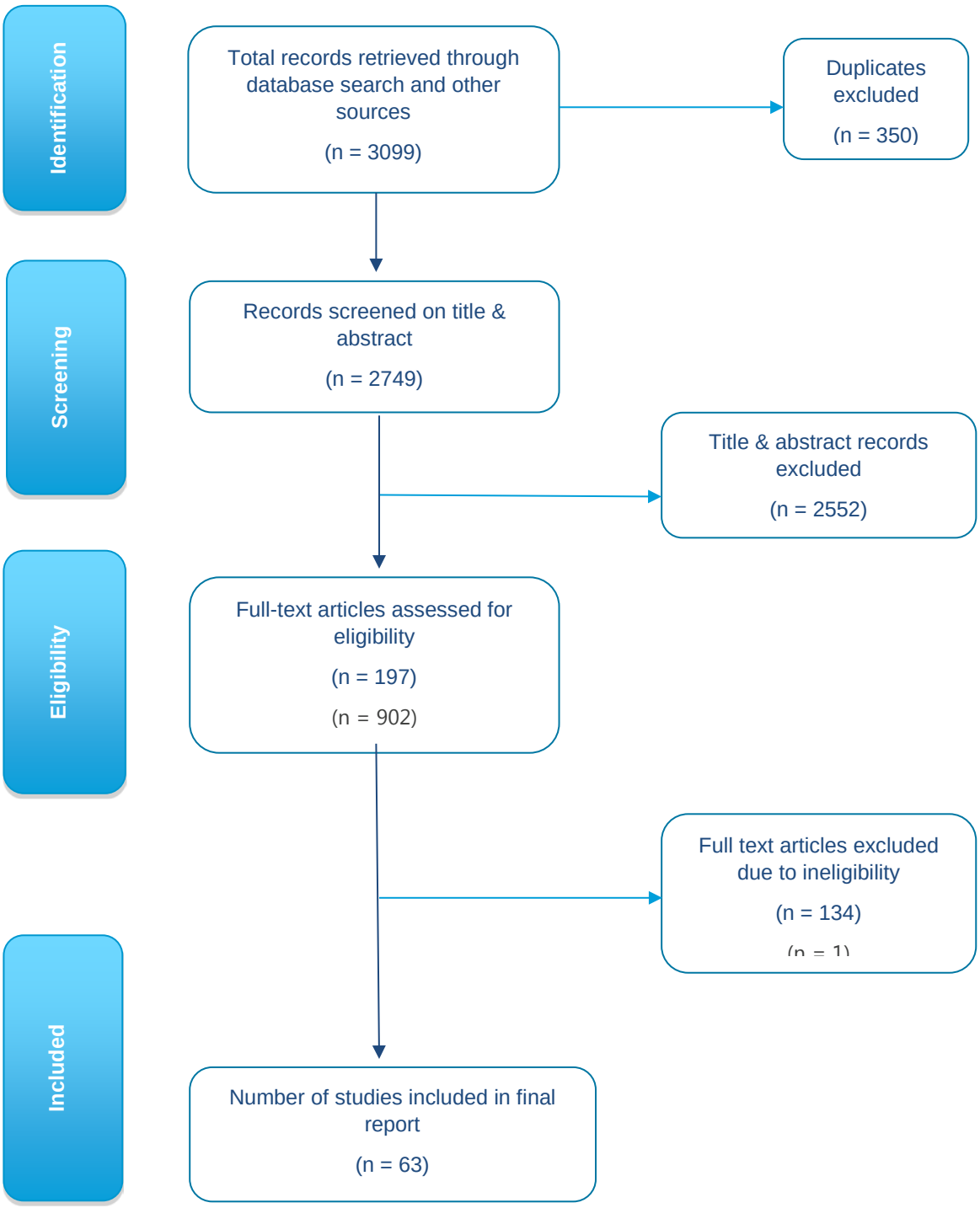
Figure X: Inclusion and exclusion criteria used to code the eligibility of references acquired through search paradigms.

Screen for questions 2 & 3	
1.	EXCLUDE language: *exclude if non-English*
2.	EXCLUDE date: *exclude if published prior to 2000*
3.	EXCLUDE demographic location: *exclude if developing country*
4.	EXCLUDE age: *exclude if age of participants > 18*
5.	EXCLUDE setting: *exclude if primary care*
6.	EXCLUDE study type: *exclude if validation study, animal study, review paper, technical report, stand-alone methods paper*
7.	EXCLUDE study group: *exclude if uncommon health conditions*
8.	EXCLUDE outcome*: exclude if variation in care due to medical insurance status (USA) and racial differences (USA)*
9.	EXCLUDE unavailable: *exclude if full-text version is not readily available*
10.	EXCLUDE quality*: exclude if response rates < 65% (international) or < 45% (Australian)*
11.	INCLUDE: *cannot be excluded so is marked as included.*

Appendix 3: Question 1 PRISMA flow-chart of included studies



Appendix 4: Questions 2 & 3 PRISMA flowchart of included studies



Appendix 5: Detailed table of included studies – inpatient

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Adams (2001)[25]	**Aim:** Study factors associated with dispensing of anti-inflammatory (controller) asthma medication to children in 3 managed care organisations US ED Inpatient Outpatient Secondary data analysis 3 geographically varied metropolitan areas **Measures:** Primary outcome: frequency of asthma controller therapy dispensing	Asthma N=13,352 children Mean age: 9.3 years Range: 3–15 years	Children aged 3–5 years were less likely to be dispensed any controller medication than older children ($p<0.001$) Among children dispensed 6 or more beta agonists, only 39% also received 5 or more controller dispensings, with adolescents significantly less likely than younger children to receive 5 or more controllers ($p<0.001$) • Significant geographical variation in proportions of patients dispensed controller medication	Unwarranted Effective Patient and geographical area	Yes
Antonow (2001)[59]	**Aim:** Describe variation in the performance of sepsis evaluations in infants with bronchiolitis US Inpatient Chart review (retrospective) 10 paediatric hospitals **Measures:** Primary outcome: rate of sepsis evaluations	Bronchiolitis N=303 (175 with sepsis evaluation, 270 bronchiolitis) Mean age: 49 days (range: 0–90 days) Apr 1995–Sept 1996	There was a statistically significant difference in the incidence of sepsis evaluations across sites ($p<0.001$) Incidence of PICU admission, average length of stay (LOS), and mean total costs were significantly different across sites ($p<0.003$) The sepsis evaluation group was more likely to have been admitted to PICU, have a longer LOS, and higher total costs as well as higher mean severity and were significantly younger	Unwarranted Preference-sensitive Health service Unwarranted Cannot say Health service Unwarranted Cannot say	No

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
	Other outcomes: intensive care stay, LOS, total costs		(p<0.006)	Health service	
Bratton (2005)[60]	**Aim:** Determine use of asthma therapies when patients did not respond to standard therapy of inhaled corticosteroids and were admitted to PICU US Inpatient – PICUs in 41 hospitals who are members of Pediatric Health Information System (PHIS) Geographical area (based on US Census data) Secondary data analysis **Measures:** Primary outcome: use of mechanical ventilation across regions Other measures: compliance with WHO Global Initiative for Asthma pocket guide for treatment of severe asthma exacerbations, including use of inhaled anticholinergic medications (effective care) and systemic use of magnesium, methylxanthines and beta agonists (preference-sensitive care)	Asthma N=7125 Median age: 5.9 years 2000–2003	Mechanical intubation varied by 6%–27% across geographical regions (adjusted for severity) Use of beta agonists did not differ between children who were ventilated and those who were not. Among ventilated children, use of methylxanthine ranged from 0.6%–59% across regions while use of magnesium ranged from 15%–46%	Unwarranted Preference-sensitive Geographical Unwarranted Preference-sensitive & effective Geographical	No

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Brogan (2012)[27]	**Aim:** Evaluate variation in healthcare resource use and its association with clinical outcomes in children with community acquired pneumonia (CAP) US Inpatient Secondary data analysis Multiple sites: 29 hospitals contributing data to the PHIS **Measures:** Primary outcome: patient-level variation in care by age Other measures: hospital-level variation: LOS, probability of readmission and probability of ED return visits within 14 days	Pneumonia Median age 3 years (range 1–18 years) July 2005–June 2010	Little patient-level variation by age except CRP, ESR and serum electrolytes more commonly ordered in older children. Older children more likely to have combination antibiotics prescribed Marked hospital-level variation LOS – median 2 days, range 1.5–3.5 days. Return to ED: range 0.9%–4.9%. Readmission range: 1.5%–4.5%	Unwarranted Effective: CRP and ESR not warranted in diagnosis of pneumonia Preference-sensitive: no clear national consensus in US for the management of children with pneumonia Health service Unwarranted Cannot say Health service	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Brownell (2002)[61]	**Aim:** Determine (1) age- and sex-standardised rates of tonsillectomy by (i) geographical areas of Manitoba and (ii) neighbourhood income levels (quintiles) in 1994/95, 1996/97 and 1998/99, following introduction of a clinical practice guideline (CPG) re: tonsillectomy in June 1995; (2) case load volume by practitioner location for children aged < 3 years Canada Inpatient Secondary data analysis **Measures:** Primary outcome: rates of tonsillectomy by regional health authority across the 3 time points Other measures: tonsillectomy rates by income quintile across rural and non-rural regions. Tonsillectomy rates for children < 3 years by practitioner location	Tonsillectomy & adenoidectomy Patient/practitioner number not reported Age range 0–19 years	Tonsillectomy rates fell overall after the introduction of CPGs but rose again in 1998/99 Children living outside the main city were 30.5% more likely to have their tonsils removed. Removal was highest for children in the top vs middle or lowest income quintile No change in rates of tonsillectomy for children aged 3 years or younger	Unwarranted Preference-sensitive Geographical and patient income	No

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Chisolm (2006)[31]	**Aim:** Assess variation in asthma care – i.e. use of systemic corticosteroids, metered-dose inhaler use and pulse oximetry use – before and after hospital implementation of asthma order sets US Inpatient Secondary data analysis Single site – Columbus Children's Hospital, Ohio **Measures:** Primary outcome: hospital data system capturing order sets used combined with hospital decision support system to capture asthma diagnosis Other measures: LOS, healthcare costs	Asthma Age range: 2–20 years N=261 'pre-set' patients, 63 'no set' patients, 466 'set' cases	Significant variation in asthma care by use of order sets with better care (i.e. use of corticosteroids, metered-dose inhalers and pulse oximetry) when order sets accessed. Variation in corticosteroids: 78%–94%, metered-dose inhalers: 40%–56%, oximetry: 83%–91% LOS and costs did not differ by use of order sets	Unwarranted Effective Practitioner	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Ennis (2013)[35]	**Aim:** Examine variation in paediatric rehabilitation for traumatic brain injury (TBI) relating to school re-entry and management of cognitive and communication impairments US Inpatient Retrospective cohort Chart review 9 acute rehabilitation institutions **Measures:** Primary outcome: variation in report of strategies for encouraging school re-entry and managing cognitive and communication impairments. Strategies identified through Delphi process	TBI N=174 children Age range: 0–17 years	Variation in school re-entry services ranged from 0%–92% within and across the 9 sites Variation in management of strategies ranged from 49.6%–96.5%	Unwarranted Preference-sensitive Health service	Yes
Fedeli (2009)[40]	**Aim:** Investigate variability in tonsillectomy and/or adenoidectomy rates in children from Veneto region Italy Inpatient Secondary data analysis 21 local health districts **Measures:** Primary outcome: rates of tonsillectomy and adenoidectomy (T & A) and T & A over time. Variation in rates of adenoidectomy, tonsillectomy and T & A across health regions and by child gender and non-Italian status	T & A N=15,096 tonsillectomies and/or adenoidectomies performed Age range: 2–9 years	The number of overall T & A surgeries declined from 2000 to 2003 and then remained stable Wide variation in T & A rates between the 21 health districts, from < 5 to > 25 T & A per 1000 person years Non-Italians 8.8 T & A per 1000 person years compared with 14.9 for Italians Males more likely to have T & A than females	Unwarranted Preference-sensitive Geographical	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Florin (2014)[62]	**Aim:** Describe variation across USA in use of resources not recommended for bronchiolitis care and to examine association between resource use and disposition outcomes US Inpatient Secondary data analysis 42 hospitals contributing to the PHIS **Measures:** Primary outcome: variation in use of albuterol, adrenaline, systemic steroids, CXR and antibiotics Other measures: association between use of these 5 resources and LOS and readmission within 3, 7 and 14 days for bronchiolitis	Bronchiolitis N=64,994 infants Mean age 3.7 months (SD 3.2 months)	Greatest variation use of albuterol (3.5%–81%), adrenaline (0.6%–78%) and CXR (24%–76.7%), even after adjusting for age, gender, year, illness severity and insurance status Use of the 5 resources was associated with increased LOS. Only antibiotic use was associated with readmission and it was associated with decreased odds of readmission	Unwarranted Effective Health service	No
Foster (2013)[12]	**Aim:** Document awareness and use of CPGs for procedural pain in neonates, including use of breastfeeding and sucrose and whether pain assessment tool is used Australia Inpatient Survey Response rate: 91% Hospitals across the country	Analgesia & sedation 196 practitioners (representing hospital)	39% of hospitals used a CPG with wide variation between states and type/size of neonatal service Breastfeeding use varied from 38%–100% across units. Sucrose use varied from 31%–100% across units. Pain assessment tool more likely to be used in NICU (50%) than postnatal (0%) or SCN (8%)	Unwarranted Effective Health service Unwarranted Effective (breastfeeding/sucrose) and preference-sensitive (pain assessment tool)	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
	Measures: Primary outcome: awareness and use of CPGs for pain Other measures: use of breastfeeding and sucrose for pain Use of pain assessment tool			Health service	
Gerber (2010)[63]	**Aim:** Document variation in use of antibiotics and use of broad spectrum antibiotics across hospitals US Inpatient Secondary data analysis 40 hospitals contributing data to the PHIS **Measures:** Primary outcome: variation in hospital rates of use of antibiotics, adjusted patient-level (e.g. age, gender), hospital-level and resource use (as proxy of disease severity i.e. LOS, case mix index). Variation in hospital rates of use of broad spectrum antibiotics	Antibiotic use N=336,088 children Age range: 0–17 years	60% of children received at least 1 dose of antibiotics. Wide variation in use, varying from 368 to 601 days/1000 patient days. Wide variation in use of broad spectrum antibiotics Hospitals who tended to use antibiotics more also tended to use broad spectrum antibiotics more and use antibiotics for longer periods	Unwarranted Effective Health service	No
Goyal (2013)[11]	**Aim:** (1) determine the percentage of patients admitted, with and without obstructive sleep apnoea (OSA) or complex chronic conditions, and (2) identify practice variations in postoperative admission after T & A US Inpatient Outpatient Secondary data analysis Multiple sites – 24 children's hospitals in the USA	T & A N=29,920 cases from 24/43 hospitals with complete data Age range: 0–18 years	Admission rates vary by age – higher if younger; higher if any of the following: OSA, comorbidities, or OSA+ comorbidities Between hospital variation in admission rates (5%–90%) for 3–5 yearr olds, even after controlling for age, comorbidities and OSA.	Warranted and unwarranted (sicker patients more likely to be admitted overall, but this did not explain all of the variation) Effective Patient Unwarranted	No

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
	with admin data in the PHIS database **Measures:** Primary outcome: admitted vs not admitted: variation by age, OSA and comorbidities			Preference-sensitive Health service	
Kanal (2011)[64]	**Aim:** To examine variation in paediatric trauma head CT imaging protocols US Inpatient Survey Multiple trauma centres across Washington state Response rate: 76% **Measures:** Primary outcome: paediatric trauma volumes, CT dose reduction strategies, and effective dose by trauma centre levels	Concussion/TBI N=51 centres 2215 children received head CT scans	There is variation both within and between trauma centres in paediatric head CT imaging protocols and radiation dose in Washington state	Unwarranted Preference-sensitive Health service & practitioner	No
Kenyon (2014)[26]	**Aim:** To assess timing of asthma rehospitalisation, variation in rate of rehospitalisation and factors associated with rehospitalisation at different intervals US Inpatient Secondary data analysis 42 hospitals across the US **Measures:** Primary outcome: variation in re-	Asthma N=7603 patients rehospitalised of 44,024 admissions Age range: 2–18 years	Wide variation across readmission rates with median 1.6% (IQR 1.3%–2.3%) at 7 days and median 17.1% (IQR 15.1%–18.8%) at 365 days Patients with public insurance and black patients had higher odds of rehospitalisation at 60 days and beyond Adolescents, patients with a complex chronic condition and patients with prior year hospital admission had higher rates of rehospitalisation	Unwarranted Cannot say Health service, patient type	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
	hospitalisation rates		Significant hospital variation in case mix-adjusted rates of rehospitalisation at each time interval		
Landrigan (2008)[36]	**Aim:** To measure variation in paediatric hospitalists' reported use of common inpatient therapies, and to test the hypothesis that variation in reported use of proven therapies is lower than variation in reported use of unproven therapies US Inpatient Survey Response rate: 66% Practitioners across the US **Measures:** Primary outcome: frequency of using 14 therapies in the management of common conditions	Asthma, bronchiolitis, gastroenteritis, GERD N=213 paediatric hospitalists	Little variability existed in reported use of albuterol and corticosteroids in asthma and systemic dexamethasone in bronchiolitis Moderate to high variation existed in reported use of all other therapies studied: inhaled therapies for bronchiolitis was high; moderate variability in the use of rapid IV hydration, lactobacillus and ondansetron for children hospitalised with gastroenteritis; moderate to high variability in the management of GERD Variation in reported use of proven therapies (albuterol, corticosteroids, ipratropium in the first 24 hours for asthma, IV rehydration for gastroenteritis) was significantly less than variation in reported use of unproven therapies	Unwarranted Effective & preference-sensitive Health practitioner	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Langhan (2012)[45]	**Aim:** Describe the frequency of different physiologic monitoring modalities and combinations of modalities used during paediatric procedural sedation; to describe variation by different classes of patients, health care providers (i.e. anaesthesiologists, ED physicians, nurse practitioners), procedures and sedative medications employed; and to determine the proportion of sedations meeting published guidelines US Inpatient Outpatient ED Secondary data analysis (Sept 2007–March 2011) Multiple sites: 37 institutions comprising the Pediatric Sedation Research Consortium (large children's hospitals, children's hospitals within hospitals, and general/ community hospitals, self-selected for involvement in the paediatric sedation research consortium data sharing group) **Measures:** Primary outcome: demographics, procedure performed, provider level, adverse events, medications and physiologic monitors used	Analgesia & sedation N=114,855 children Median age: 48 months Range: < 1–252 months	Large variation in frequency of use of each physiologic monitoring modality by health care provider type, medication used and procedure performed. Largest difference in monitoring use was seen between providers using electrocardiography (13%–95%). Guidelines published by the American Academy of Pediatrics, the American College of Emergency Physicians, and the American Society of Anesthesiologists for non-anaesthesiologists were adhered to for 52% of subjects	Unwarranted Preference-sensitive Practitioner Unwarranted Preference-sensitive (guidelines based on expert opinion) Practitioner	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Leyenaar (2014)[65]	**Aim:** Describe patterns of diagnostic testing and antibiotic use in uncomplicated pneumonia in general vs children's hospitals and to determine association between diagnostic testing and LOS US Inpatient Secondary data analysis Range of hospitals representing 15% of all USA hospitals **Measures:** Primary outcome: variation in use of CRP, blood cultures, viral testing and use and type of antibiotics LOS by use of resources	Pneumonia N=17,299 Median age: 3 years Range: 1–7 years	Greatest variation in viral respiratory testing: 0%–80%, CRP: 0%–80%, blood cultures ~ 40%–100% Children's vs general hospitals more likely to prescribe cephalosporin together with anti-staph antibiotics Use of blood cultures associated with longer LOS i.e. 1 additional day for every 7 children having a blood culture taken	Unwarranted Effective Health service	No
Mahant (2014)[28]	**Aim:** Describe variation in use of dexamethasone, antibiotics and revisits to hospital within 30 days post-tonsillectomy US Inpatient Secondary data analysis 36 hospitals giving data to the PHIS database **Measures:** Primary outcome: prescribing of dexamethasone and antibiotics. 30-day tonsillectomy-related revisits to the hospital	T & A N=139,715 Mean age: 7 years Range: 1–18 years	Dexamethasone prescribing ranged from 0.3%–98.8% Antibiotic prescribing (unwarranted) ranged from 2.7%–92.6% Hospital revisit ranged from 3%–12.6% Revisit for bleeding ranged from 1%–8.8% and for vomiting/dehydration from 0.3%–4.4%	Unwarranted Effective Health service	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
McAlearney (2006)[34]	**Aim:** Evaluate the use of 3 evidence-based computerised order sets (asthma, post-appendectomy care and CAP), and examine patient and admission characteristics associated with order set utilisation US Inpatient Outpatient Retrospective study (Nov 2001 to Nov 2003) Single site: Columbus Children's Hospital, Ohio **Measures:** Primary outcome: order set use rate, factors associated with order set use	Asthma Pneumonia Post-appendectomy care N=529 asthma patients, 277 appendectomy patients and 210 CAP patients Age range: 2–20 years	Order set utilisation varied by condition ($p<0.001$), with the asthma order set use rate highest (88.1%), followed by appendectomy (79.4%) and substantially lower CAP order set use (21.1%). Only the asthma order set showed a trend of increasing use after implementation ($z=-3.02$, $p=0.002$)	Unwarranted Effective Practitioner	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
McCulloh (2012)[44]	**Aim:** Identify quality indicators for the evaluation and treatment of children hospitalised with bronchiolitis based on guidelines and assess differences in adherence rates to these indicators between hospitalist and non-hospitalist paediatricians US Inpatient Retrospective chart review 2 hospitals **Measures:** Primary outcome: adherence to guideline 2b (minimising bronchodilator use): data collected on evaluation, treatment, LOS, readmission and adverse outcomes	Bronchiolitis N=713 Mean age: 0.47 years (site 1), 0.54 years (site 2) Age range: 0.2–1.84 years (site 1), 0.2–1.91 years (site 2)	Hospitalists better adhere to selected portions of the American Academy of Pediatrics bronchiolitis guidelines, thus providing higher quality of care Hospitalists discontinued unnecessary systemic corticosteroid therapy (75.0% vs 42.4%; p=.001) and antibiotic therapy (71.0% vs 48.6%; p=.007) more frequently than non-hospitalists	Unwarranted Effective Practitioner	Yes
Patrick (2012)[41]	**Aim:** To identify characteristics associated with the practice of performing lumbar punctures for suspected early onset neonatal sepsis in a nationally representative sample US Inpatient Secondary data analysis Multiple hospitals across the USA (nationally representative sample) **Measures:** Primary outcome: frequency and characteristics of newborns that underwent a lumbar puncture for EONS	Early onset neonatal sepsis N=13,694 Age range: up to 21 days	National variation in lumbar punctures performed for early onset neonatal sepsis among normal-birthweight infants, even when adjusting for clinical conditions Newborns having lumbar punctures were more likely to be covered by Medicaid vs private insurance (p<0.001), be born in urban vs rural hospitals (p<0.001), teaching vs non-teaching (p<0.001) and children's hospitals vs non-children's (p<0.001) Newborns having lumbar punctures performed were disproportionately born in the Northeast census region (p=0.03)	Unwarranted Preference-sensitive Health service/practitioner	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Rangel (2011)[37]	**Aim:** Examine (1) trends in the use of antibiotic prophylaxis for commonly performed operations, (2) appropriateness in the context of available guidelines, and (3) adverse events potentially attributable to antibiotic prophylaxis US Inpatient Secondary data analysis 22 hospitals from PHIS database **Measures:** Primary outcome: procedure-specific use rates for antibiotic prophylaxis, use rates based on appropriate and inappropriate indications Other outcomes: adverse event rates	Antibiotic use Median number of cases per hospital=23,435 (range, 4212–36,129) Median age: 3.3 years	Significant variation in the use of antibiotic prophylaxis in surgery: 82% of the children received antibiotics during procedures when antibiotic prophylaxis was indicated (range 60%–96% by hospital), and 40% of the patients received antibiotics when there was no indication (range, 10%–83%) The likelihood of receiving antibiotic prophylaxis was significantly different between hospitals for all procedures examined ($p < 0001$) Adverse events were significantly more frequent in children receiving antibiotic prophylaxis than in those who did not ($p < .0001$)	Unwarranted Effective Practitioner Unwarranted Effective Practitioner	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Rice-Townsend (2014)[38]	**Aim:** Characterise scope and magnitude of variation in diagnosis and treatment of appendicitis US Inpatient ED Secondary data analysis PHIS database for 34 hospitals from Sept 2010 to Sept 2011 **Measures:** Primary outcome: pre-operative imaging (CT or ultrasound) and blood tests. Post-operative imaging (CT or ultrasound), use of IV antibiotics, use of PICC line, use of parental nutrition (complicated appendicitis only) Other measures: Costs of hospitalisation by complicated vs uncomplicated appendicitis	Appendicitis N=13,328 Age range: 3–18 years Median: 10 (IQR 8–13 years)	Significant variation found for all measures. 3.5-fold difference in pre-op imaging (21.2%–73.5%) and fivefold difference in pre-op blood tests For patients with complicated appendicitis: 12-fold difference in post-op imaging (4.9%–61.6%), 48-fold difference in use of PICC line (1.7%–81.8%) and 100-fold difference in use of parental nutrition (0.4%–42%) Costs of hospitalisation varied fourfold for uncomplicated and 4.6-fold for complicated appendicitis.	Unwarranted Effective: good evidence for which antibiotics should be used and lack of need for PICC lines in uncomplicated cases Preference-sensitive: lack of evidence to inform other aspects of diagnosis and management of appendicitis Health service Unwarranted Cannot say if effective, preference-sensitive or supply-sensitive variation Health service	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
Suleman (2010)[46]	**Aim:** Describe extent of variation in tonsillectomy rates by geographic region and explore whether any variation is due to private vs public surgeries UK Inpatient Secondary data analysis Data from across all NHS hospitals and BUPA private data **Measures:** Primary outcome: T&A rates	T & A N=380 NHS areas Age range: 0–15 years	Rates varied from 102 to 754 per 100,000 population (sevenfold variation). Variation not explained by private surgeries	Unwarranted Preference-sensitive Geographic area	Yes
Tieder (2013)[54]	**Aim:** To characterise variation in hospital resource utilisation and readmission for diabetic ketoacidosis across USA children's hospitals US Inpatient Secondary data analysis 38 children's hospitals **Measures:** Primary outcome: resource utilisation. Other measures: overall and non-ICU LOS, and readmission for diabetic ketoacidosis within 30 and 365 days	Diabetes N=24,890 diabetic ketoacidosis admissions Age range: 2–18 years	Even after adjusting for difference in patient characteristics across hospitals, widespread differences existed across hospitals in resource use (total standardised cost), LOS and readmission rates ($p<.001$). Hospital bed days overall and, in particular, the non-ICU portion, accounted for the majority of the total standardised cost per hospitalisation (overall 57%; non-ICU 36%) and explained most of the variation in resource use	Unwarranted Supply-sensitive Health service	Yes

Paper	Study details	Population	Key findings	Variation Type and area	Associated factors reported?
To (2010)[52]	**Aim:** To use population-based data to measure the associations and to explain the variations of appendectomy rates by socio-demographic indicators Canada – Ontario Inpatient Secondary data analysis **Measures:** Primary outcome: geographic variations in appendectomy rates by district health councils. Relationships between rates and sociodemographic variables	Appendicitis N=24,047 Age range: 0–18 years	Regions with higher percentage of rural living had higher positive, negative and perforated appendectomy rates. There was an almost fourfold variation in negative appendectomies across regions. Rural living negatively associated with ultrasound use Increased availability of surgeons associated with lower negative appendectomy rates and lower perforated appendicitis	Unwarranted Effective Geographical Unwarranted Supply-sensitive Geographical	Yes
Womer (2014)[66]	**Aim:** To evaluate variation in hospital opioid use in paediatric patients US Inpatient Secondary data analysis 626 hospitals **Measures:** Primary outcome: Prescription of opioid. Other measures: duration of opioid use and clinical and hospital level (children's vs general hospital, volume of patient factors associated with use)	Analgesia & sedation N=approx 2.3 million patients Age range: 0–20 years, mostly teenagers (15–20 years)	Opioid exposure varied across sites, as did length of use Increased opioid exposure associated with increased age and LOS and with children's vs general hospitals. Duration of exposure ranged from 1–8.4 days, even after adjusting for patient demographics, clinical conditions, and hospital type and volume.	Unwarranted Preference-sensitive Hospital	No

Appendix 6: Detailed table of included studies – outpatient care

Paper	Study details	Population	Key findings
Adams (2001)[25]	**Aim:** Study factors associated with dispensing of anti-inflammatory (controller) asthma medication to children in 3 managed care organisations US ED Inpatient Outpatient Secondary data analysis 3 geographically varied metropolitan areas **Measures:** Primary outcome: frequency of asthma controller therapy dispensing	Asthma N=13,352 children Mean age: 9.3 years Range: 3–15 years	Children aged 3–5 years were less likely to be dispensed any controller medication than older children ($p<0.001$) Among children dispensed 6 or more beta agonists, only 39% also received 5 or more controller dispensings, with adolescents significantly less likely than younger children to receive 5 or more controllers ($p<0.001$) Significant geographical variation in proportions of patients dispensed controller medication
Bergman (2006)[21]	**Aim:** Quantify the individual effects of the patient's clinical presentation, demographic, provider and practice characteristics, and regional variables on practice variability in the evaluation and treatment of febrile infants US Outpatient Secondary data analysis (Feb 1995 and April 1998, Pediatric Research in Office Settings, the practice-based research network of the American Academy of Pediatrics) Country level **Measures:** Primary outcome: hospitalisation, lumbar puncture, urinalysis and/or urine culture, blood work and initial antibiotic administration	Febrile infants N=2712 infants and 484 providers located in 194 practices Mean age: 48.9 days (range 0–93 days) Providers: 45 years	Variation in the treatment of febrile infants. Differences in clinical presentation and severity of illness underlie much of the observed practice variability among paediatricians evaluating and treating febrile infants

Paper	Study details	Population	Key findings
Bhatara (2007)[20]	**Aim:** Compare the use of atomoxetine with that of stimulant medications in children and adolescents and examine the predictors of atomoxetine use in ADHD US Outpatient ED Secondary data analysis – outpatient department portion of the 2003–04 National Hospital Ambulatory Medical Care Survey and the 2003–04 National Ambulatory Medical Care Survey **Measures:** Primary outcome: use of atomoxetine and stimulants Predictors of atomoxetine use	ADHD medication Age: < 20 years N=14.51 million visits involved psychotropic agents of which 1361 were for atomoxetine	10% of all psychotropic visits were for atomoxetine vs 40% for stimulants. Use of atomoxetine varied by age (most preferred in 10–14 year olds), region and insurance status (more use in private) Use of atomoxetine did not vary by sex, race, psychiatric comorbidity, primary care status or metropolitan location
Bruckner (2012)[17]	**Aim:** Examine whether the use of prescription medications to treat ADHD varies positively with supply-side healthcare characteristics US (2734 counties) Outpatient Secondary data analysis Country level: nationally representative sample of 35,000 USA pharmacies in 2001–03 **Measures:** Primary outcome: change in retail prescription purchases for ADHD medications from 2001–03 Other measures: area per capita income and prescription rates. School individualised education programs	ADHD N=35,000 pharmacies Age: not reported	Retail prescription purchases increased by 33.2% from 2001 to 2003

Paper	Study details	Population	Key findings
Cabana (2003)[67]	**Aim** Determine (i) documentation of asthma severity and (ii) documentation of quality asthma care between charts where severity was/was not documented US Outpatient Chart review (stratified, random sample of charts of 10 asthma patients/site) Multiple sites (9 paediatric clinics in Michigan, US) **Measures:** Primary outcome: documentation of asthma severity Other outcomes: documentation of influenza immunisation, asthma action plan, asthma education, prescription of a spacer device and prescription of a peak flow meter	Asthma N=280 patients and 28 paediatricians Mean/median: 6.8 years (IQR 2.3–10.7 years)	Only 34% of charts had asthma severity documented and poorer quality of all aspects of asthma care in charts where asthma severity was not documented (e.g. variation in spacer prescription (27%–32%), peak flow meter prescription (6%–25%) and asthma action plan (5%–27%).
Dorsey (2005)[15]	**Aim:** Determine rates of diagnosis and types of treatment among overweight children in 2 community and 2 hospital clinics US Outpatient Chart review (600 chart records between Jan 1999 and Dec 2000) Multiple sites: 4 clinics in New Haven **Measures:** Primary outcome: evidence for treatment of overweight including diet modification, increase physical activity follow-up, referral to subspecialist and testing for metabolic syndrome Other measures: documentation of BMI and overweight diagnosis	Obesity N=150 patients and 28 providers (paediatricians, GPs, nurse practitioners) Age range: 3–17 years	Treatment ranged from 6%–34% across the clinics. Dietary change (74%) followed by physical activity (49%) most commonly recommended. Only 14% referred to subspecialist and 3% tested for metabolic comorbidities BMI only recorded in 0.5% of records. Rates of overweight diagnosis ranged from 12%–37% and undiagnosed ranged from 63%–88%

Paper	Study details	Population	Key findings
Gaur (2005)[43]	**Aim:** Evaluate differences in use of antibiotics for viral respiratory tract infections by junior vs senior hospital staff US Outpatient Country Secondary data analysis (National Hospital Ambulatory Medical Care Survey database 1995–2000) **Measures:** Primary outcome: variation in care by doctor seniority (junior vs staff physician) Other measures: variation in care by teaching vs non-teaching hospital setting	Antibiotics use N=1952 Age: 0–18 years	Junior doctors less likely to prescribe antibiotics (19.5%) than senior doctors (36.4%) Doctors at teaching hospitals less likely to prescribe antibiotics than doctors at non-teaching hospitals
Gellad (2014)[53]	**Aim:** Describe proportion of children prescribed ADHD medication who also receive non-pharmacological therapy (psychology) and to describe variation by USA county US Outpatient Secondary data analysis (insurance database from Jan 2010 to Dec 2010) Country level **Measures:** Primary outcome: variation in receipt of therapy overall and by quintile of county psychologist supply	ADHD N=301,530 Mean age: 11.6 years Range: 0–17 years	Psychology therapy receipt varied by county ranging from 6.3%–38.1% Variation in receipt of psychology therapy occurred even across counties with a similar number of psychologists

Paper	Study details	Population	Key findings
Goyal (2013)[11]	**Aim:** (1) Determine the percentage of patients admitted, based on their age, with and without OSA or complex chronic conditions across 24 paediatric hospitals in the country, and (2) to identify practice variations, if any, in postoperative admission after T & A US Inpatient Outpatient Chart review (retrospective database) Multiple sites – 24 children's hospitals in the USA with admin data in the PHIS database **Measures:** Primary outcome: admitted vs not admitted – does this vary by age, OSA and comorbidities	T & A N=29,920 cases from 24/43 hospitals with complete data Age range: 0–18 years	Admission rates vary by age – higher if younger, higher if any of OSA, comorbidities, or OSA+ comorbiditie Between hospital variation in admission rates (5%–90%) for 3–5 year olds, even after controlling for age, comorbidities and OSA
Gunasekera (2009)[16]	**Aim:** Determine whether Australian Aboriginal Medical Service practitioners treat otitis media more aggressively in Aboriginal than non-Aboriginal children and the factors influencing their management decisions Australia Outpatient Survey Multiple sites – medical practitioners working in Aboriginal health services Response rate: 55% of eligible practitioners from 72% of eligible services **Measures:** Primary outcome: management of otitis media in ATSI vs non-ATSI children Other measures: demographics, burden of otitis media in their practice, method of diagnosis	Otitis media N=63 Aboriginal Medical Service, 131 of 238 eligible doctors Practitioner age: > 20 years	Practitioners more likely to prescribe antibiotics if Aboriginal child compared with non-Aboriginal. Child (58% vs 21% for otitis media with effusion and 92% vs 49% for acute otitis media) Most practitioners saw otitis media every week, used otoscopy correctly, identified the diagnosis in the case vignettes. Few practitioners used pneumatic otoscopy or tympanometry (which are the only reliable techniques diagnosing middle ear effusions)

Paper	Study details	Population	Key findings
Gupta (2014)[13]	**Aim:** Estimate the rates of parent-reported vs physician-diagnosed food allergy, (2) determine paediatrician adherence to national guidelines, and (3) obtain paediatricians' perspectives on guideline non-adherence US Outpatient Mixed method approach: survey, chart review, qualitative methods Multiple sites: 3 Chicago paediatric clinics Response rate: not reported **Measures:** Primary outcome: rate of parent-reported food allergy Other measures: adherence with National Institute of Allergy and Infectious Diseases guidelines and paediatricians' perspectives on the above results	Food allergy N=459 children (50 with allergy) and 49 records reviewed Age range: 0–18 yrs	10.9% parents reported food allergy (two-thirds detected by paediatrician) and 74% had discussed with paediatrician 26% of parents did not discuss allergy with paediatrician because already diagnosed with another doctor, not severe enough, avoid food anyway, other more important concerns to discuss High rates of guideline adherence with respect to allergist referral (67.3%) but less so for documentation of reaction history (38.8%), appropriate use of diagnostic tests (34.7%), prescription of autoinjectors (44.9%) and counselling families in food allergy management (24.5%)
Hoagwood (2000)[19]	**Aim:** Determine (1) types of services physicians were providing to children who received stimulants, (2) what factors predicted receipt of stimulants, and (3) whether these practices were concordant or discordant with professional consensus on diagnosis and treatment of ADHD US Outpatient Chart review from physicians taking part in the 1995 National Ambulatory Medical Care Survey Country level **Measures:** Primary outcome: management practices for stimulant prescription visits vs non-stimulant psychopharmacology visits Other measures: paed/psych/GP variation in management for stimulant medication visits	ADHD N=1883 physicians and 36,875 sample records Age range of patients: 0–17 years	Physicians more likely to provide diagnostic service, counselling and specific follow-up for stimulant medication visit vs other psychotropic medications during visits (not significant), but psychotherapy was more likely to be provided in visits during which other psychotropic medications rather than stimulants were prescribed (46.2% vs 21.6%, $p<0.01$) Psychiatrists more likely than either paediatrician or family practitioners to provide psychotherapy and more likely than paediatricians to specify a follow-up but less likely to provide other health counselling

Paper	Study details	Population	Key findings
Langhan (2012)[45]	**Aim:** Describe the frequency of different physiologic monitoring modalities and combinations of modalities used during paediatric procedural sedation; to describe how physiologic monitoring varies among different classes of patients, healthcare providers (i.e. ranging from anaesthesiologists to emergency medicine physicians to nurse practitioners), procedures and sedative medications employed; and to determine the proportion of sedations meeting published guidelines for physiologic monitoring US Inpatient Outpatient ED Secondary data analysis (large multicentre database from 1 Sept 2007 to 31 March 2011) Multiple sites: 37 institutions comprising the Pediatric Sedation Research Consortium (large children's hospitals, children's hospitals within hospitals and general/community hospitals, self-selected for involvement in the Pediatric Sedation Research Consortium data-sharing group) **Measures:** Primary outcome: data including demographics, procedure performed, provider level, adverse events, medications and physiologic monitors used	Analgesia & sedation N=114,855 children. Median age: 48 months Range: < 1–252 months	Large variation in frequency of use of each physiologic monitoring modality by health care provider type, medication used, and procedure performed. Largest difference in monitoring use was seen between providers using electrocardiography (13%–95%). Adherence to CPGs published by the American Academy of Pediatrics, American College of Emergency Physicians and the American Society of Anesthesiologists for non-anaesthesiologists was 52%

Paper	Study details	Population	Key findings
Mabry (2005)[42]	**Aim:** Medical record review of children initially diagnosed with obesity at a general paediatrics visit US Outpatient Chart review (outpatient claim between Jan 1997 and Dec 2002) Multiple sites: 9 university-affiliated outpatient clinics **Measures** Primary outcome: obesity diagnosis at general paediatrics visit	Obesity N=171 children and 44 paediatricians Mean age: 10.7 (SD 3.3). Range: 2–18 Only looking at index visits for overweight status	The diagnosis was made most often at health maintenance visits (46%). BMI was documented in 5% of initial visits; 74% had documentation of obesity-related history; 64% had documentation of counselling. Variations in initial evaluation and management at index visits Female patients were less likely than male patients to have a diet history documented (52% vs 69%; p=0.02) but more likely to have documentation of a referral to a weight loss program (17% vs 1%; p<0.01) Female gender physician was associated with increased documentation of activity counselling (51% vs 34%; p=0.03), recommendation of a follow-up appointment (42% vs 27%; p=0.03), and weight loss program referral (15% vs 4%; p=0.03)
Mahmood (2007)[47]	**Aim:** Evaluate the trends in radiological follow-up of childhood pneumonia among consultant paediatricians throughout the UK UK Outpatient Country level Survey (Jan and March 2001) Response rate: 73% **Measures:** Primary outcome: children admitted offered a clinical follow-up, repeat chest radiograph on follow-up is arranged, and if there are guidelines for the follow-up of these children, time of follow-up chest radiography	Pneumonia N=120 Age not reported	Only 23% of the respondents worked in units with written guidelines for the follow-up of children with pneumonia Unnecessary number of chest radiographs performed: 18% of consultant paediatricians would carry out a follow-up chest radiograph on all patients with pneumonia Early timing of repeat chest radiograph: 8 paediatricians would repeat the chest radiograph at 2–3 weeks following pneumonia, which is considered early

Paper	Study details	Population	Key findings
McAlearney (2006)[34]	**Aim:** Evaluate the use of three evidence-based computerised order sets (asthma, post-appendectomy care and CAP, and examine patient and admission characteristics associated with order set utilisation in paediatrics US Inpatient Outpatient Retrospective study (Nov 2001 to Nov 2003) Single site: Columbus Children's hospital, Ohio **Measures:** Primary outcome: order set use rate, factors associated with order set use	Asthma Pneumonia Post-appendectomy care N=529 asthma patients, 277 appendectomy patients and 210 CAP patients Age range: 2–20 years	Order set utilisation varied by condition ($p<0.001$), with the asthma order set use rate highest (88.1%), followed by appendectomy (79.4%) and substantially lower CAP order set use (21.1%). Only the asthma order set showed a trend of increasing use after implementation ($z=-3.02$, $p=0.002$)
Morawetz (2014)[18]	**Aim:** Determine Australian paediatricians' knowledge and management of IgE-mediated food allergy Australia Outpatient Survey Country level: members of Australian Paediatric Research Network Response rate: 43% **Measures:** Primary outcome: use of skin prick testing, serum IgE testing and knowledge of correct use of adrenaline auto-injector pens	Allergy including adrenaline auto injectors N=93 Age range of paeds: 25–65 years.	Use of skin prick testing varied by practitioner location (100% rural, 64% regional and 88% metropolitan). Use of serum IgE testing less common with 80% rural, 71% regional and 74% metro Knowledge of correct use of auto-injector varied and was poor for factors including child age < 5 years and child taking a beta-blocker

Paper	Study details	Population	Key findings
Parr (2006)[32]	**Aim:** Evaluate consultant paediatrician choice of IV bronchodilator for acute severe asthma and their awareness of subsequent hypokalaemia UK Outpatient Survey Regional areas: Oxford, Mersey & South Thames Response rate: 81% **Measures:** Primary outcome: clinical practice in the use of either IV salbutamol or aminophylline Other measures: opinions regarding the potential side effects of hypokalaemia	Asthma N=137 Age not reported	Of the non-PICU consultants who responded, 82%, including respiratory paediatricians, reported using aminophylline rather than salbutamol; in contrast, PICU consultants were significantly more likely to use salbutamol (90%, p=<0.001) Lack of awareness that hypokalaemia occurs with aminophylline: 50% of the consultants suggested that hypokalaemia was rare or did not occur. Consultants using IV aminophylline were significantly less likely to recheck serum potassium levels than those using IV salbutamol (p=0.03)
Rhodes (2006)[30]	**Aim:** Describe attitudes, barriers and practices related to type 2 diabetes screening in children among paediatric clinicians US Outpatient Survey Geographical area: Harvard Vanguard Medical Associates (large multispecialty group practice with population ~71,000 children in 14 practices in eastern Massachusetts) Response rate: 69% **Measures:** Primary outcome: screening practices with 3 hypothetical clinical vignettes representing low, moderately high, and high risk for type 2 diabetes	Diabetes N=62 clinicians Age: 71% aged 36–55 years; < 36: 8%; > 55: 21%	Based on intent to screen in the 3 vignettes, 21% of respondents reported American Diabetes Association-consistent screening practice, 39% screened also the low-risk patient and 35% screened only the high-risk patient Many clinicians ordered screening tests other than those recommended by the American Diabetes Association; few (<9% in any vignette) ordered only an American Diabetes Association-recommended test

Paper	Study details	Population	Key findings
Zoëga (2011)[14]	**Aim:** Explore the accessibility of ADHD drugs and the prevalence of their use among children, adolescents and adults in the 5 Nordic countries: Denmark, Finland, Iceland, Norway and Sweden Northern Europe Outpatient Secondary data analysis (Data on dispensed ADHD drugs from Jan 2007 to Dec 2007 from nationwide prescription databases) Geographical level: 5 Nordic countries **Measures:** Primary outcome: prevalence of prescription at population levels, compared between countries and age-adjusted	ADHD N=68,776 Age: 0–27 years prescribed ADHD meds, but reported specifically on 7–15 years to capture children's data	Significant differences in total use of ADHD drugs between the Nordic countries, where relatively homogeneous populations, similar culture and national healthcare systems exist. Drug use for ADHD is the least in Finland but most in Iceland. Methylphenidate is the most commonly used drug in all five Nordic countries

Appendix 7: **Detailed table of included studies – emergency department**

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Adams (2001)[25]	**Aim:** Study factors associated with dispensing of anti-inflammatory (controller) asthma medication to children in 3 managed care organisations US ED Inpatient Outpatient Secondary data analysis 3 geographically varied metropolitan areas **Measures:** Primary outcome: frequency of asthma controller therapy dispensing	Asthma N=13,352 children Mean age: 9.3 years Range: 3–15 years	Children aged 3–5 years were less likely to be dispensed any controller medication than older children ($p<0.001$) Among children dispensed 6 or more beta agonists, only 39% also received 5 or more controller dispensings, with adolescents significantly less likely than younger children to receive 5 or more controllers ($p<0.001$) Significant geographical variation in proportions of patients dispensed controller medication	Unwarranted Effective Patient and geographical area	Yes
Alak (2010)[68]	**Aim:** Assess compliance with evidence-based guidelines for the management of pneumonia, including variations in tests and antimicrobials Canada ED Chart review Single site **Measures:** Primary outcome: compliance with management guidelines Choice of antimicrobial agent for children with pneumonia	Pneumonia N=816 children Range: 3 months to 18 years 2000 to 2007	Compliance with CPGs varied by child age: 59.7% in children 5–18 years old and 83.0% in children 3 months to 5 years old Most variation in antibiotic prescribing	Unwarranted Preference-sensitive (as CPGs for older children less evidence-based) Practitioner	No

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Babl (2008)[48]	**Aim:** Compare CPG recommendations and reported physician management of acute asthma Australia and New Zealand ED – 9 Australian, 2 New Zealand sites Physician survey Response rate: 94% (78/83 ED physicians) **Measures:** Primary outcome: CPGs for mild to moderate asthma Senior ED physician management of acute paediatric asthma	Asthma 78 ED physicians Age not reported	1. CPGs for management of mild asthma were consistent across the 11 sites: no variation 2. Variation in CPGs and in physician practice increased with disease severity 3. All sites recommended salbutamol and ipratropium, but delivery methods varied e.g. for severe to critical asthma – nebulised delivery of salbutamol preferred by 79% of doctors over metered dose inhalers. For critical asthma – IV aminophylline used by 45%, IV magnesium by 55% and IV salbutamol by 87% 4. Thirty-nine different dosing regimens for IV salbutamol reported	Unwarranted Preference-sensitive as less quality evidence for management of severe to critical asthma than mild to moderate asthma Practitioner	Yes

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Babl (2009)[33]	**Aim:** Establish current acute seizure management through a review of CPGs and reported physician management and to compare this with Advanced Paediatric Life Support guidelines. Australia and New Zealand ED – 9 Australian, 2 New Zealand sites Physician survey Response rate: 78/83 ED physician (94%) **Measures:** Primary outcome: review of CPGs for acute seizure management Survey investigating management of status epilepticus	Status epilepticus 78 ED physicians Age not reported	10 sites used 7 different seizure CPGs. One site had no seizure CPG Initial seizure management by CPG and reported physician practice broadly similar across sites and consistent with Advanced Paediatric Life Support guidelines. Variation in practice (medications used and route given; timing of intubation) for second/third line management.	Unwarranted Preference-sensitive Health service Limited variation Unwarranted Preference-sensitive: lack of evidence re: which medications to use and best route Supply-sensitive: lack of ICU beds precluding intubation Practitioner	Yes

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Barrios (2012)[69]	**Aim:** Investigate the management of patients with diabetic ketoacidosis presenting to EDs US ED Physician survey Chart review 116 EDs Response rate: 94% **Measures:** Primary outcome: physician report on the clinical practice management of diabetic ketoacidosis	Diabetes Age not reported	Only 34% (39 EDs) had a documented diabetic ketoacidosis guideline/policy Of these, only 74% (28/39) specifically addressed paediatrics and only 55% addressed monitoring and treatment of cerebral oedema Variation in use of IV fluids for treatment e.g. ~ 80% would give IV isotonic sodium chloride during the first hour but 17%–21% would use an alternative choice not supported by evidence i.e. administering initial IV solution of 0.45 sodium chloride, initiating an insulin drip before fluids, or waiting for more laboratory results before giving fluids or insulin	Unwarranted Effective Health service Unwarranted Effective Health service Unwarranted Effective Health servic	No

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Bhatara (2007)[20]	**Aim:** Compare the use of atomoxetine with that of stimulant medications in children and adolescents and examine the predictors of atomoxetine use in ADHD US Outpatient ED Secondary data analysis – outpatient department portion of the 2003–04 National Hospital Ambulatory Medical Care Survey and the 2003–04 National Ambulatory Medical Care Survey **Measures:** Primary outcome: use of atomoxetine and stimulants Predictors of atomoxetine use	ADHD medication Age: < 20 years N=14.51 million visits involved psychotropic agents of which 1361 were for atomoxetine	10% of all psychotropic visits were for atomoxetine vs 40% for stimulants. Use of atomoxetine varied by age (most preferred in 10–14 year olds), region and insurance status (more use in private) Use of atomoxetine did not vary by sex, race, psychiatric comorbidity, primary care status or metropolitan location	Unwarranted Preference-sensitive Practitioner Geographical – northeast vs southern USA region	Yes
Bourgeois (2014)[49]	**Aim:** Measure the hospital-level variation in admission rates for children receiving treatment for common paediatric illnesses across EDs in USA children's hospitals US ED – 35 paediatric tertiary care hospitals Secondary data analysis: PHIS between 1 Jan 2009 and 31 Dec 2012 **Measures:** Primary outcome: admission rate Other measures: condition severity	Asthma Bronchiolitis Concussion Pneumonia UTI N=1, 288,706 Age: 0–19 years Median: 3 years	Greater than threefold variation in severity-adjusted admission rates for common paediatric conditions across hospitals Highest variation for concussion (range 5%–72%), followed by pneumonia (19%–69%), and bronchiolitis (19%–65%). The least variation was found among patients presenting with seizures (7%–37%) and kidney and urinary tract infections (6%–37%) Although variability existed in disease-specific admission rates, certain hospitals had consistently higher, and others consistently lower, admission rates	Unwarranted Effective – lack of standardised guidelines for admissions Supply-sensitive – lack of primary care, leading to increased admissions Health service	Yes

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Goldman (2009)[50]	**Aim:** Characterise variations in treatment decisions for young febrile infants in paediatric EDs and document extent of practice variations among paediatric ED practitioners Canada ED – 6 paediatric EDs Prospective cohort study Response rate: 70% of eligible infants recruited **Measures:** Primary outcome: variation in treatment decisions Other measures: tests ordered and antibiotics prescribed	Fever N=257 infants Mean age 48.7 (+/- 23.6) days	Variation in antipyretic use and IV fluids across centres % of antibiotics prescribed similar across centres but choice of antibiotics used varied Variation in tests ordered, especially lumbar punctures and X-rays Little variation in disposition between EDs	Unwarranted Effective: lumbar punctures underperformed Preference-sensitive: lack of high quality evidence to inform all aspects of management Practitioner	Yes

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Isaacman (2001)[51]	**Aim:** Compare the management approaches between general emergency medicine physicians and paediatric emergency medicine physicians and correlate them to existing practice guidelines US ED Chart review 1 children's hospital ED and 1 general ED during 1998–99	Fever ≥ 39.4 ˚C with no source N=568 children at paediatric ED N=81 at general ED Age range: 3–36 months Mean: 16.3 months (paediatric ED) and 18 months (general ED)	Paediatric emergency medicine physicians ordered more complete blood counts (324/568 vs 27/81), more blood cultures (321/568 vs 27/81) and more urine cultures (208/568 vs 20/81) General emergency medicine physicians ordered more CXRs and cerebrospinal fluid analyses than paediatric emergency medicine physicians General emergency medicine physicians diagnosed more focal infections (109/228 vs 526/1323) General emergency medicine physicians conflicted more often with the practice guidelines (66/79 vs 225/498)	Unwarranted Effective Practitioner	Yes
Jain (2002)[70]	**Aim:** Evaluate the patterns of ceftriaxone use in an urban paediatric ED and determine if overuse exists based on CPGs US ED – single site Chart review **Measures:** Primary outcome: indication for ceftriaxone compared with 1993 CPGs	Fever N=229 Age: 3 months to 18 years	180/229 had an identifiable focus of infection Ceftriaxone use was justified in 16.6%, questionable 17% and not justified in 66.4%	Unwarranted Effective Practitioner	No

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Kelly (2003)[57]	**Aim:** Characterise presentations due to acute asthma at EDs, including their severity, treatment and disposition Australia ED – 38 sites (adult and paediatric) Prospective cohort: 2000 to 2001 **Measures:** Primary outcome: treatment administered	Asthma N=892 Age: < 16 years	Underuse of corticosteroids in children with moderate or severe asthma Underuse of oxygen in severe asthma Low rate of spacers to deliver beta agonist treatment	Unwarranted Effective Practitioner	Yes
Kool (2014)[29]	**Aim:** Describe differences in providers' use of analgesia, observation, CT imaging and discharge disposal for 3 case vignettes New Zealand ED – 2 metropolitan paediatric EDs and one urgent care clinic Survey using purposeful sample of paediatricians **Measures:** Primary outcome: analgesia prescription, use of CT and referral decisions for follow-up	Concussion/TBI N=29 clinicians Age: 25 to > 45 years	Most providers followed NICE guidelines for analgesia. Most indicated children be observed in hospital Variation in use of CT, written advice to parents and in decisions around referral for follow-up	Unwarranted Preference-sensitive: management based on expert opinion, not evidence Effective: NICE guidelines state that all patients should be followed up Practitioner	Yes

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Langhan (2012)[45]	**Aim:** Describe the frequency of different physiologic monitoring modalities used during paediatric procedural sedation and variation by patients, healthcare providers, procedures, and sedative medications employed; and to determine the proportion of sedations meeting published guidelines for physiologic monitoring US Inpatient Outpatient ED } 37 children's & mixed hospitals Prospective cohort study. Sept 2007 to 31 March 2011 **Measures:** Primary outcome: procedure performed, provider level, medications, physiologic monitors used, demographics	Analgesia & sedation N=114,855 Age median: 48 months IQR: 23–96 months	Large variation in frequency of use of each physiologic monitoring modality by healthcare provider type, medication used and procedure performed. Largest difference in monitoring use was seen between providers using electrocardiography (13%–95%) Adherence to CPGs published by the American Academy of Pediatrics, the American College of Emergency Physicians and the American Society of Anesthesiologists for non-anaesthesiologists was 52%	Unwarranted Preference-sensitive Practitioner Unwarranted Preference-sensitive (guidelines based on expert opinion) Practitioner	Yes
Mansbach (2005)[23]	**Aim:** Describe the epidemiology of USA ED visits for bronchiolitis, including the characteristics of children presenting and variability in care US ED – general hospitals Secondary data analysis 1992 to 2000 **Measures:** Primary outcome: ED visit rates for bronchiolitis and medications received	Bronchiolitis N=1,868,000 visits Age: < 2 years	Wide ED practice variability for which there is little or no supporting evidence e.g. use of beta agonists 53% (95% CI 41%–61%); received antibiotics 37% (95% CI 21%–53%) and received systemic corticosteroids 13% (95% CI 4%–22%) Children more likely to receive steroids were coded urgent status in triage and were boys	Unwarranted Effective Practitioner Warranted (disease severity-dependent) Practitioner	No

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Massin (2006)[71]	**Aim:** Analyse the management in the ED and correlate it to existing practice guidelines Belgium ED – single site Chart review **Measures:** Primary outcome: final diagnosis, diagnostic and treatment approach, adherence to guidelines	Fever N=376 Age range: 1–36 months Mean: 13.8 (+/- 9.7) months Patients excluded if chronic illness, recent antibiotic use, focal bacterial infection or typical viral illness	In children < 3 months: guideline compliance varied from 100% (urinalysis), 97% (WBC count) to 29% (blood culture) In children 3–36 months: guideline compliance varied from 91% (urinalysis in boys under < 1 year) to 82% (CXR if temperature > 39 °C and WBC > 20,000/mm3) Use of CXR when not indicated and prescription of empirical antibiotic therapy conflicted with guidelines	Unwarranted Effective Practitioner	No

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Neuman (2011)[72]	**Aim:** Examine the use of CXR among children with pneumonia and other respiratory illnesses to investigate inter-institution CXR use and to identify if there is a relationship between CXR use and rate of pneumonia US ED – 25 EDs contributing to PHIS database from 2003 to 2008 Secondary data analysis **Measures:** Primary outcome: use of CXR for patients with a diagnosis of pneumonia or upper respiratory tract illness, wheeze and fever Other measures: hospital-specific rates of CXR use	Pneumonia N=8,386,716	The use of CXR varied widely among paediatric EDs but did not appear to influence the institution-specific rate of pneumonia. The proportion of children with a diagnosis of pneumonia that had a CXR ranged from 38%–88%. CXRs were more frequent among younger children and infants Wide variation in the use of CXR for diagnoses other than pneumonia e.g. upper respiratory tract infection (range, 9%–36%), wheeze (14%–56%), fever (7%–41%) The rate of use of CXR for patients hospitalised with other diagnoses was higher than respective rates of CXR use for discharged patients e.g. upper respiratory tract infection, 68% vs 16%; wheeze, 57% vs 23%; and fever, 45% vs 18% (all $p<$ 0.001)	Effective Unwarranted Health service	No

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Ochoa (2012)[55]	**Aim:** Describe the variability and appropriateness of the diagnostic and therapeutic procedures used in bronchiolitis Spain ED – 10 EDs with at least 100 bronchiolitis cases Secondary data analysis as part of the Bronchiolitis – Study of Variability, Adequacy, and Adherence Oct 2007 to March 2008 **Measures:** Primary outcome: appropriateness of the treatments Other measures: main treatments, diagnostic tests used and main results	Bronchiolitis N=2032 Age range: 3 months to 1 year Mean: 0.53 years	64% of the treatments used in the acute phase and the 55.9% in the treatment phase were considered inappropriate Variation in the use of all diagnostic tests e.g. CXR (13.6%–45.3%), CRP (0%–22.3%), RSV identification tests (0%–43.3%) Variation in the use of all treatments e.g. oral steroids (0%–44%), beta agonists (11.2%–85.2%) and antibiotics (3.9%–33.3%)	Effective Unwarranted Practitioner	Yes

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Plint (2004)[22]	**Aim:** (1) Characterise management of bronchiolitis in paediatric EDs and (2) determine patient outcomes following ED visit Canada ED – 7 tertiary care children's hospitals Prospective consecutive cohort study during a 7–21-day period. Included chart review then telephone follow-up at 2–3 weeks post-visit Response rate: 189 patients (80%) interview and chart review; 48 (20%) chart review only; follow-up 163 (69%) **Measures:** Primary outcome: variation in the use of bronchodilators and steroids by site Other measures: investigations in the ED, patient outcomes	Bronchiolitis N=237	73% of patients (range per site 59%–100%) were treated in the ED with bronchodilators (usually salbutamol or epinephrine) and 5% (range per site 0%–14%) with oral steroids Significant practice variation by site in ED bronchodilator use ($p<0.001$) and bronchodilator use at discharge ($p=0.0003$) Admission rates (range 22%–43%) increased in younger children, children with comorbidities, and children with lower oxygen saturation	Effective Unwarranted Health service Warranted: disease severity-dependent Health service	Yes

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Rice-Townsend (2014)[38]	**Aim:** Characterise scope and magnitude of variation in diagnosis and treatment of appendicitis US Inpatient ED Secondary data analysis: PHIS database for 34 hospitals from Sept 2010 to Sept 2011 **Measures:** Primary outcome: pre-operative imaging (CT or ultrasound) and blood tests. Post-operative imaging (CT or ultrasound), use of IV antibiotics, use of PICC line, use of parental nutrition (complicated appendicitis only) Other measures: costs of hospitalisation by complicated vs uncomplicated appendicitis	Appendicitis N=13,328 Age range: 3–18 years Median: 10 (IQR 8–13 years)	Significant variation found for all measures. 3.5-fold difference in pre-op imaging (21.2%–73.5%) and fivefold difference in pre-op blood tests For patients with complicated appendicitis: 12-fold difference in post-op imaging (4.9%–61.6%), 48-fold difference in use of PICC line (1.7%–81.8%) and 100-fold difference in use of parental nutrition (0.4%–42%) Costs of hospitalisation varied fourfold for uncomplicated and 4.6-fold for complicated appendicitis	Unwarranted Effective: good evidence for which antibiotics should be used and lack of need for PICC lines in uncomplicated cases Preference-sensitive: lack of evidence to inform other aspects of diagnosis and management of appendicitis Health service Unwarranted Cannot say if effective, preference-sensitive or supply-sensitive variation Health service	Yes

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Schnadower (2014)[73]	**Aim:** Document variation in patient disposition and clinical factors associated with management of febrile infants with culture-proven UTIs US ED – 19 paediatric EDs in the Pediatric Emergency Medicine Collaborative Research Committee Secondary data analysis **Measures:** Primary outcome: proportion of patients managed as outpatients per site Other measures: laboratory testing associated with outpatient management	UTI N=1764 Age range: 29–60 days	Proportion of infants managed as outpatients varied from 0%–20% across sites Clinical site most important factor associated with discharge from ED followed by presence of upper respiratory tract infection symptoms, absence of vomiting and < 10 WBC/μL on CSF	Effective Unwarranted Health service Preference-sensitive Unwarranted Health service	No
Schuh (2012)[58]	**Aim:** Examine use of beta2 agonists via metered dose inhalers with oral and inhaled corticosteroids at discharge Canada ED – 6 tertiary care paediatric Sept 2008 and March 2009 Chart review **Measures:** Primary outcome: proportion of children prescribed 'comprehensive therapy', i.e. albuterol via metered dose inhaler with oral and inhaled corticosteroids Other measures: pharmacotherapy used in ED and at discharge	Asthma N=656 Age range: 2–17 years Median: 5 years	Overall rate of comprehensive therapy was 382/654 (58%), which varied from 30%–84% ($p<0.0001$) Only 58% of patients without inhaled corticosteroids on arrival were offered inhaled corticosteroids at discharge. There was significant variation in the rates of all discharge pharmacotherapies across centres	Effective Unwarranted Practitioner Effective Unwarranted Practitioner	Yes

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Stanley (2007)[56]	**Aim:** Examine the prevalence of, and the factors associated with, variation in the use of CXRs and blood testing for paediatric patients with asthma US ED – 25 EDs in the USA in the Pediatric Emergency Care Applied Research Network Chart review **Measures:** Primary outcome: use of ancillary testing for asthma – blood test or CXR	Asthma N=734 Mean age: 6.3 years (SD 4.6 years) Range 1–18 years	41% received any testing – 27% had a CXR, 14% had bloods (not blood gases) Variation in care by practitioner training i.e. children with asthma treated by emergency or paediatric physicians without paediatric ED training were more likely to undergo blood testing	Effective Unwarranted Practitioner Effective Unwarranted Practitioner	Yes
Uspal (2013)[24]	**Aim:** Determine factors associated with the use of procedural sedation during incision and drainage procedures at a tertiary children's hospital US ED – single tertiary urban paediatric hospital Nested cohort study that combined a retrospective medical record review with prospectively collected data for children who had an incision and drainage procedure performed over a 1-year period **Measures** Primary outcome: use of sedation	Analgesia & sedation N=215 Median age: 5 years Range: 2 months to 18 years	44% received procedural sedation. In those not sedated, 62% received topical local anaesthetic, 24% topical and injected local anaesthetic, 5% injected only and 8% nothing Younger patients and those with larger lesions were more likely to have procedural sedation. Physician experience and ED volumes did not affect variation	Preference-sensitive Unwarranted: provider frequency of sedation Practitioner Warranted: larger abscess size (disease severity) and younger child Practitioner	Yes

Paper	Study details	Population	Key findings	Variation type and level	Association factors reported?
Widger (2009)[39]	**Aim:** Examine how acute paediatric asthma is managed across hospitals and to compare practice with standard international guidelines Ireland ED Survey – paediatricians working in 17 centres Response rate: 30/54 (55.5%) paediatricians and 17/18 (94%) centres **Measures:** Primary outcome: presence of hospital having a guideline for asthma management Other measures: drug use, spacer use, written action plan use.	Asthma	13 (76.4%) centres had a written protocol for the management of acute asthma, of whom 11 used their own protocol, 2 used British Thoracic Society alone and 1 used Advanced Paediatric Life Support guidelines alone Dosage of medicines used via spacers and metered dose inhalers varied across sites Availability of written action plans varied from 0–5 available from the ED and 0–9 available from the ward Use of first-line IV bronchodilators varied i.e. 47% used IV salbutamol, 43% used IV aminophylline, 3% used magnesium. Oxygen saturation thresholds used for the administration of oxygen and in decisions regarding admission varied between paediatricians	Effective Unwarranted Health service Effective Unwarranted Health service Unwarranted Effective Health service Unwarranted Effective (first-line IV treatment) and supply-sensitive (admission) Practitioner	Yes

Appendix 8: Quality assessment of surveys

Paper	Setting	Response rate	Sample population representative of the background population?	Information given on how non-respondents differ from respondents?	Missing data?	Missing data appropriately addressed?	Validated tools used?
Foster (2013)[12]	Inpatient	91%	No	No	Yes (non-responders)	No	No
Kanal (2011)[64]	Inpatient	76%	Unclear	No	Yes (non-responding centres)	No but response bias discussed as limitation	No
Landrigan (2008)[36]	Inpatient	67%	Unclear	No	Yes (non-responders)	No	No but piloted and Likert scale used
Gunasekera (2009)[16]	Outpatient	55%	Unclear	No	Yes (non-responders)	No but discussed as limitation	No but survey pilot tested
Gupta (2014)[13]	Outpatient	Not reported (mixed methods study)	Unclear	No	Yes (non-responders)	No	No
Mahmood (2007)[47]	Outpatient	73%	Unclear but sampling stratified to ensure an even distribution of consultants from across UK	No	Yes (non-responders)	No	No
Morawetz (2014)[18]	Outpatient	43%	No	Yes	No	N/A	No
Parr (2006)[32]	Outpatient	81%	No	No	Yes (non-responders)	No	No
Rhodes (2006)[30]	Outpatient	69%	No	No	Yes (non-responders)	No	No but questions taken from various frameworks

Paper	Setting	Response rate	Sample population representative of the background population?	Information given on how non-respondents differ from respondents?	Missing data?	Missing data appropriately addressed?	Validated tools used?
							and scales
Babl (2008)[48]	ED	94%	No	No	Yes (non-responders)	No	No but survey tool was reviewed by all site representatives to capture local management variation
Babl (2009)[33]	ED	94%	Unclear	No	Yes (non-responders)	No	No (Info) The survey tool was reviewed by all site representatives to capture local management variation
Barrios (2012)[69]	ED	94%	Unclear	No	Yes (facilities that did not respond: defined age ranges for each facility's paediatric patient and their corresponding annual ED paediatric volume)	No	No but reviewed extensively
Kool (2014)[29]	ED	Purposeful sample	No	No	Yes (non-responders)	No but bias of using purposeful sample discussed as limitation	No but piloted
Widger (2009)[39]	ED	Individual reply rate 55.5%; centre reply rate 94%	Unclear	No	Yes (non-responders)	No	No

Appendix 9: Associated factors for variation in inpatient care

Paper	Condition	Key findings	Associated factors
Adams (2001)[25]	Asthma	Children aged 3–5 years were less likely to be dispensed any controller medication than older children ($p<0.001$) Among children dispensed 6 or more beta agonists, only 39% also received 5 or more controller dispensings, with adolescents significantly less likely than younger children to receive 5 or more controllers ($p<0.001$) Significant geographical variation in proportions of patients dispensed controller medication	1, 2 and 3. Limited patient adherence because many children have both frequent dispensing of bronchodilators and one dispensing of controller but do not get refills of controller meds (**proposed**) 1, 2 and 3. Less frequent physician visits (unable to schedule routine and timely follow-ups to monitor clinical situation for children started on controller meds as recommended by guidelines) (**proposed**) 1, 2 and 3. External influences e.g. adolescents not being allowed to carry medication on their person while at school (**proposed**)
Brogan (2012)[27]	Pneumonia	Little patient-level variation by age except CRP, ESR and serum electrolytes more commonly ordered in older children. Older children more likely to have combination antibiotics prescribed Marked hospital-level variation LOS – median 2 days, range 1.5–3.5. Return to ED: range 0.9%–4.9% Readmission range: 1.5%–4.5%	1 and 2. Lack of established guidelines for diagnosis and management of pneumonia **(proposed)** 1 and 2. Increased testing may have occurred due to variation in institutional practice patterns – i.e. processes may beget further testing, more interventions, increased costs and longer LOS **(proposed)** 2. Hospital variation in efficiency of discharge process **(proposed)** 2. Variation in outpatient care affecting re-admission rates **(proposed)** 2. Inadequate education of family members at discharge could have affected 14-day ED revisit rates **(proposed)**

Paper	Condition	Key findings	Associated factors
Chisolm (2006)[31]	Asthma	Significant variation in asthma care by use of order sets with better care (i.e. use of corticosteroids, metered-dose inhalers and pulse oximetry) when order sets accessed. Variation in corticosteroids: 78%–94% metered-dose inhalers: 40%–56% oximetry: 83% to 91%	1. Informal, social communication fostered attitudes to order set use (from focus groups) **(actual)** 1. High use for the asthma order set was commonly attributed to its high quality and time savings made **(actual)** 1. Use of evidence-based order sets increased use of evidence-based practices **(actual)** 1. No extra steps involved in using order set (i.e. don't have to do literature search themselves or ask anyone) **(actual)** 1. Key factors are degree of awareness that order set exists and perceived quality of order set **(actual)** 1. Education around order sets must be continuous (especially where user turnover is high e.g. in resident years) and multimodal, formal and informal **(actual)** 1. Having clinical ownership is important but to make a good order set, ownership must be combined with commitment to standardisation and access to high quality evidence **(actual)**
Ennis (2013)[35]	Concussion/TBI	Variation in school re-entry services ranged from 0%–92% within and across the 9 sites Variation in management of strategies ranged from 49.6%–96.5%	1 and 2. Institutional restraints and lack of resources **(proposed)** 1. A higher prevalence of published evidence on cognitive and communication deficits after TBI compared to school re-entry may have contributed **(proposed)**
Fedeli (2009)[40]	T & A	The number of overall T & A surgeries declined from 2000–03 and then remained stable Wide variation in T & A rates between the 21 health districts, from < 5 to > 25 T & A per 1000 person years Non-Italians 8.8 T & A per 1000 person years compared with 14.9 for Italians	2. Clinical uncertainty about indications for T & A **(proposed)** 2. Surgeons' general propensity to perform T & A rather than underlying disease per se **(proposed)** 3. Non-Italians may receive different patterns of care and diagnosis from Italians **(proposed)**

Paper	Condition	Key findings	Associated factors
Foster (2013)[12]	Analgesia & sedation	39% of hospitals used a CPG with wide variation between states and type/size of neonatal service Breastfeeding use varied from 38%–100% across units. Sucrose use varied form 31%–100% across units. Pain assessment tool more likely to be used in NICU (50%) than postnatal (0%) or SCN (8%)	1. Lack of clinician awareness of policy directive in NSW (only state with such a directive) to use a CPG for pain management **(proposed)** 2. Type of setting i.e. NICU vs SCN or postnatal ward **(actual)** 2. Number of births/annum and higher level care units **(actual)**
Kenyon (2014)[26]	Asthma	Wide variation across readmission rates with median 1.6% (IQR 1.3–2.3) at 7 days and median 17.1% (IQR 15.1%–18.8%) at 365 days Patients with public insurance and black patients had higher odds of rehospitalisation at 60 days and beyond Adolescents, patients with a complex chronic condition and patients with prior year hospital admission had higher rates of rehospitalisation Significant hospital variation in case mix-adjusted rates of rehospitalisation at each time interval	1. Local provider adherence to CPGs **(proposed)** 1, 2, 3 and 4. Access to primary care, pharmacies, school-based care or hospitals **(proposed)** 3. Patient adherence to controller medication (**proposed)**

Paper	Condition	Key findings	Associated factors
Landrigan (2008)[36]	Asthma, bronchiolitis, gastroenteritis, GERD	Little variability existed in the reported use of albuterol and corticosteroids in asthma and systemic dexamethasone in bronchiolitis Moderate to high variation existed in reported use of all other therapies studied: inhaled therapies for bronchiolitis was high; moderate variability in the use of rapid IV hydration, lactobacillus and ondansetron for children hospitalised with gastroenteritis; moderate to high variability in the management of GERD Variation in reported use of proven therapies (albuterol, corticosteroids, ipratropium in the first 24 hours for asthma, IV rehydration for gastroenteritis) was significantly less than variation in reported use of unproven therapies	2. Gaps in knowledge, lack of evidence base to support day-to-day practice **(proposed)**
Langhan (2012)[45]	Analgesia & sedation	Large variation in frequency of use of each physiologic monitoring modality by healthcare provider type, medication used and procedure performed. Largest difference in monitoring use was seen between providers using electrocardiography (13%–95%) Adherence to CPGs published by the American Academy of Pediatrics, the American College of Emergency Physicians and the American Society of Anesthesiologists for non-anaesthesiologists was 52%	CPGs contain confusing language which is difficult to interpret (**proposed**) Adherence to guideline-based monitoring may not reduce adverse events and not appropriate for certain settings (**proposed**)
Mahant (2014)[28]	T & A	Dexamethasone prescribing ranged from 0.3%–98.8% Antibiotic prescribing (unwarranted) ranged from 2.7%–92.6%. Hospital revisit ranged from 3%–12.6% Revisit for bleeding ranged from 1%–8.8% and for vomiting/dehydration from 0.3%–4.4%	2. Variation in revisits may reflect variation in surgical technique, pain management, parent education, follow-up care **(proposed)**

Paper	Condition	Key findings	Associated factors
McAlearney (2006)[34]	Asthma Pneumonia Post-appendectomy care	Order set utilisation varied by condition ($p<0.001$), with the asthma order set use rate highest (88.1%), followed by appendectomy (79.4%) and substantially lower CAP order set use (21.1%). Only the asthma order set showed a trend of increasing use after implementation ($z=-3.02$, $p=0.002$)	1a. Case complexity – the more complex the case, the lower the utilisation of the condition-specific order set for asthma and appendectomy (**actual**) 1b. The high use of the asthma order set may reflect strong consensus among pulmonary attending physicians and nurses about this order set as an appropriate clinical pathway. High involvement of these clinicians in the order set development process prior to implementation may have translated into high use (**proposed**) 1c. For admissions to units: attending physicians on the pulmonary and surgical units who serve as strong proponents for the use of their order sets (**proposed**)
McCulloh (2012)[44]	Bronchiolitis	Hospitalists better adhere to selected portions of the American Academy of Pediatrics bronchiolitis guidelines, thus providing higher quality of care Hospitalists discontinued unnecessary systemic corticosteroid therapy (75.0% vs 42.4%; $p=.001$) and antibiotic therapy (71.0% vs 48.6%; $p=.007$) more frequently than non-hospitalist More children admitted to non-hospitalist paediatricians were transferred to the ICU than those admitted to hospitalists	3. Hospitalists have increased accessibility to respond to acute changes in patient condition without competing outpatient responsibilities **(proposed)**

Paper	Condition	Key findings	Associated factors
Patrick (2012)[41]	Neonatal sepsis	National variation in lumbar punctures performed for early onset neonatal sepsis among normal-birthweight infants, even when adjusting for clinical conditions Newborns having lumbar punctures were more likely to be covered by Medicaid vs. private insurance ($p<0.001$), be born in urban vs. rural hospitals ($p<0.001$), teaching vs. non-teaching ($p<0.001$) and children's hospitals vs. non-children's ($p<0.001$) Newborns having lumbar punctures performed were disproportionately born in the Northeast census region ($p=0.03$)	1. Inconsistent application of available clinical guidelines **(proposed)** 2. Variation in paediatrician and/or neonatologist training or differences in epidemiologic patterns that influence clinicians' perception of early onset neonatal sepsis risk **(proposed)**
Rangel (2011)[37]	Antibiotics use	Significant variation in the use of antibiotic prophylaxis in surgery: 82% of the children received antibiotics during procedures when antibiotic prophylaxis was indicated (range 60%–96% by hospital), and 40% of the patients received antibiotics when there was no indication (range, 10%–83%) The likelihood of receiving antibiotic prophylaxis was significantly different between hospitals for all procedures examined ($p<0001$) Adverse events were significantly more frequent in children receiving antibiotic prophylaxis than in those who did not ($p<.0001$)	1a. Diagnostic uncertainty **(proposed)** 1b. increasing pressure from hospitals and regulatory agencies to reduce nosocomial infection rates **(proposed)** 1c. inexperienced clinicians **(proposed)** 1d. patient preferences and patient's condition and comorbidity profile **(proposed)** 1e. Many of the current guidelines and specialty-specific recommendations used for the paediatric population are based on adult clinical data from 1979 and 1989, therefore confusion over what constitutes 'best evidence' **(proposed)**

Paper	Condition	Key findings	Associated factors
Rice-Townsend (2014)[38]	Appendicitis	Significant variation found for all measures. 3.5-fold difference in pre-op imaging and fivefold difference in pre-op blood tests. Variation most marked in patients with complicated perforated appendicitis Costs of hospitalisation varied fourfold for uncomplicated and 4.6-fold for complicated appendicitis	1. Lack of high quality clinical data to inform care (**actual**) 2a. Lower socioeconomic status families may present later and require more intensive treatment (**proposed**) 2b. Children's hospitals may see younger patients with a higher rate of complications and treatment costs (**proposed**)
Suleman (2010)[46]	T & A	Rates varied from 102–754 per 100,000 population (sevenfold variation). Variation not explained by private surgeries	1a. Lack of universally accepted guidelines **(proposed)** 1b. Variation in individual surgeon's preference **(proposed)** 1c. Parental enthusiasm for the procedure **(proposed)** 1d. Parental smoking associated with increased tonsillectomy rate (meta-analysis) **(proposed)**
Tieder (2013)[54]	Diabetes	Even after adjusting for difference in patient characteristics across hospitals, widespread differences existed across hospitals in resource use (total standardised cost), LOS and readmission rates ($p<.001$). Hospital bed days overall, and in particular the non-ICU portion, accounted for the majority of the total standardised cost per hospitalisation (overall 57%; non-ICU 36%) and explained most of the variation in resource use	1a. Bed utilisation (particularly the non-ICU portion of the hospitalisation) was main driver of variability in resource use and overall standardised cost **(actual)** 1b. Unobserved differences in patient characteristics may still exist even though this was adjusted for across hospitals **(proposed)** 1c. Inadequate adjustment for differences in hospitals' rates of patients with new-onset diabetic ketoacidosis would lead us to overestimate the degree of variability in standardised costs, LOS and readmission **(proposed)**

Paper	Condition	Key findings	Associated factors
To (2010)[52]	Appendicitis	Regions with higher percentage of rural living had higher positive, negative and perforated appendectomy rates. There was an almost fourfold variation in negative appendectomies across regions. Rural living negatively associated with ultrasound use Increased availability of surgeons associated with lower negative appendectomy rates and lower perforated appendicitis	1a. Geographical distance to available health facilities (access disparities between rural and urban) **(actual)** 1b. Ultrasound use and timely access **(actual)** 2. Availability of surgeons in the region (**actual)**

Appendix 10: Associated factors for variation in outpatient care

Paper	Condition	Key findings	Associated factors
Adams (2001)[25]	Asthma	Children aged 3–5 years were less likely to be dispensed any controller medication than older children ($p<0.001$) Among children dispensed 6 or more beta agonists, only 39% also received 5 or more controller dispensings, with adolescents significantly less likely than younger children to receive 5 or more controllers ($p<0.001$) Significant geographical variation in proportions of patients dispensed controller medication	1, 2 and 3. Limited patient adherence because many children have both frequent dispensing of bronchodilators and one dispensing of controller but do not get refills of controller meds (**proposed**) 1, 2 and 3. Less frequent physician visits (unable to schedule routine and timely follow-ups to monitor clinical situation for children started on controller meds as recommended by guidelines) (**proposed**) 1, 2 and 3. External influences e.g. adolescents not being allowed to carry medication on their person while at school (**proposed**)
Bergman (2006)[21]	Febrile infants	Variation in the treatment of febrile infants. Differences in clinical presentation and severity of illness underlie much of the observed practice variability among paediatricians evaluating and treating febrile infants	1a. Clinical characteristics of the patient alone explained 29.7% of the overall variance (**actual**) 1b. Practice site fixed effects explained nearly 15% of the overall variance (**actual**) 1c. Non-clinical characteristics of the patient, provider and practice characteristics and regional factors explained little of the variation (**actual**)
Bhatara (2007)[20]	ADHD	10% of all psychotropic visits were for atomoxetine vs 40% for stimulants. Use of atomoxetine varied by age (most preferred in 10–14 year olds), region and insurance status (more use in private)	1a. Patient and physician preferences (**proposed**) 1b. Possible better cost coverage of new medication leading to increased use in children privately insured (**proposed**)
Bruckner (2012)[17]	ADHD	Retail prescription purchases increased by 33.2% from 2001–03	1a. Supply-side healthcare factors (increase in concentration of total physicians) (**proposed**) 1b. Technical innovation of new formulations may have promoted adherence among children already diagnosed with ADHD and availability of one-a-day formulations (**proposed**)

Paper	Condition	Key findings	Associated factors
Dorsey (2005)[15]	Obesity	Treatment ranged from 6%–34% across the clinics. Dietary change (74%) followed by physical activity (49%) most commonly recommended. Only 14% referred to subspecialist and 3% tested for metabolic comorbidities	1a. Male children more commonly diagnosed and treated than female children (**actual**) 1b. Children living with 2 parents more likely to be diagnosed and treated than those living with another guardian (**actual**) 1c. Providers were slow to adhere to published practice guidelines as they perceived the guidelines as ineffective and inappropriate (**proposed**) 1d. Lack of standardised and systematic treatment strategies that incorporate behaviour modification techniques (documented treatment strategies commonly focus on recommended diet changes and less often for physical activity) (**proposed**)
Gaur (2005)[43]	Antibiotics use	Junior doctors less likely to prescribe antibiotics (19.5%) than senior doctors (36.4%) Doctors at teaching hospitals less likely to prescribe antibiotics than doctors at non-teaching hospitals	1. Junior doctors may be more aware of recent CPGs recommending against use of antibiotics in viral infections (**proposed**) 2. Staff at a teaching hospital may be able to access recent literature more easily than staff at a non-teaching hospital (**proposed**) 1 and 2. Increased use of antibiotics was associated with receiving a diagnosis of bronchitis, being seen in a non-paediatric clinic (predominantly general medicine) and being seen before the publication of the CDC/American Academy of Pediatrics guidelines (**actual**)
Gellad (2014)[53]	ADHD	Psychology therapy receipt varied by county, ranging from 6.3%–38.1% Variation in receipt of psychology therapy occurred even across counties with a similar number of psychologists	1 and 2. Parent, child or paediatrician preferences for comfort with non-pharmacologic care (**proposed**)
Gunasekera (2009)[16]	Otitis media	Practitioners more likely to prescribe antibiotics if Aboriginal child compared with non-Aboriginal child (58% vs 21% for otitis media with effusion and 92% vs 49% for acute otitis media) Most practitioners saw otitis media every week, used otoscopy correctly, identified the diagnosis in the case vignettes. Few practitioners used pneumatic otoscopy or tympanometry (which are the only reliable techniques diagnosing middle ear effusions)	1a. Child being Aboriginal (increased likelihood of acute infection) and factors making childhood acute otitis media more likely (e.g. fever, bulging red tympanic membrane). Practitioner characteristics not associated (**actual**) 1b. Driver of antibiotic choice – therapeutic guidelines (used by 75%) (**actual**) 2. Driver for rarely using pneumatic otoscopy and tympanometry – lack of equipment (**proposed**)

Paper	Condition	Key findings	Associated factors
Gupta (2014)[13]	Food allergy	High rates of guideline adherence with respect to allergist referral (67.3%) but less so for documentation of reaction history (38.8%), appropriate use of diagnostic tests (34.7%), prescription of autoinjectors (44.9%) and counselling families in food allergy management (24.5%)	1a. Poor documentation as opposed to suboptimal care (**proposed**) 1b. Lack of familiarity with guidelines and recommended practices (**proposed**) 1c. Lack of clarity of the paediatrician role in managing food allergy (**proposed**)
Hoagwood (2000)[19]	ADHD	Physicians more likely to provide diagnostic service, counselling and specific follow-up for stimulant medication visit vs other psychotropics medications during visits (not significant) but psychotherapy was more likely to be provided in visits during which other psychotropic medications rather than stimulants were prescribed (46.2% vs 21.6%, $p<0.01$) Psychiatrists more likely than either paediatrician or family practitioners to provide psychotherapy and more likely than paediatricians to specify a follow-up but less likely to provide other health counselling	1a. Living in south, white, getting mental health counselling, not getting psychotherapy, payment option other than self-pay are associated with increased probability of receiving stimulants (**actual**) 2a. Differences in severity – psychiatrists seeing more severe cases and co-occurring disorders, they have more time, trained to use this (**proposed**) 2b. Physicians other than psychiatrists not competent to provide psychotherapy (**proposed**) 2c. Differences in training or to the nature of the population seen (**proposed**) 2d. Psychotherapy may be used as alternative to stimulants in some cases (**proposed**)
Langhan (2012)[45]	Analgesia & sedation	Large variation in frequency of use of each physiologic monitoring modality by healthcare provider type, medication used and procedure performed. Largest difference in monitoring use was seen between providers using electrocardiography (13%–95%) Adherence to CPGs published by the American Academy of Pediatrics, the American College of Emergency Physicians and the American Society of Anesthesiologists for non-anaesthesiologists was 52%	1. CPGs contain confusing language which is difficult to interpret (**proposed**) 2. Adherence to guideline-based monitoring may not reduce adverse events and not appropriate for certain settings (**proposed**)

Paper	Condition	Key findings	Associated factors
Mabry (2005)[42]	Obesity	Diagnosis made most often at health maintenance visits (46%). BMI was documented in 5% of initial visits, 74% had documentation of obesity-related history, 64% had documentation of counselling. Variations in initial evaluation and management at index visits Female patients were less likely than male patients to have a diet history documented (52% vs 69%, p=0.02) but more likely to have documentation of a referral to a weight loss program (17% vs 1%, p<0.01)	1a. Multivariate analysis showed that appropriate documentation of history was associated with diet counselling (**actual**) 2a. Physician's preconceived views for the aetiology of obesity based on patient gender (**proposed**) 2b. Physician's perceived acceptability of treatment options (referring females for weight loss programs) (**proposed**)
Mahmood (2007)[47]	Pneumonia	Unnecessary number of chest radiographs performed (18% follow-up chest radiograph on all patients with pneumonia) Early timing of repeat chest radiograph: 8 paediatricians would repeat chest radiograph too early i.e. 2–3 weeks following pneumonia	1 and 2. Lack of availability and implementation of guidelines specifying the categories of children needing follow-up chest radiographs (**proposed**)
McAlearney (2006)[34]	Asthma Pneumonia Post-appendectomy care	Order set utilisation varied by condition (p<0.001), with the asthma order set use rate highest (88.1%), followed by appendectomy (79.4%), and substantially lower CAP order set use (21.1%). Only the asthma order set showed a trend of increasing use after implementation (z=−3.02, p=0.002)	1a. Case complexity – the more complex the case, the lower the utilisation of the condition-specific order set for asthma and appendectomy (**actual**) 1b. The high use of the asthma order set may reflect strong consensus among pulmonary attending physicians and nurses about this order set as an appropriate clinical pathway. High involvement of these clinicians in the order set development process prior to implementation may have translated into high use (**proposed**) 1c. For admissions to units: attending physicians on the pulmonary and surgical units who serve as strong proponents for the use of their order sets (**proposed**)
Parr (2006)[32]	Asthma	82% of non-PICU consultants, including respiratory paediatricians, reported using aminophylline rather than salbutamol; in contrast, PICU consultants were significantly more likely to use salbutamol (90%, p=<0.001) 50% of the consultants suggested that hypokalaemia was rare or did not occur. Consultants using IV aminophylline were significantly less likely to recheck serum potassium levels than those using IV salbutamol (p=0.03)	1. Lack of standardised clinical practice: despite publication of the BTS/SIGN guidelines, some unit protocols did not allow the use of IV salbutamol outside the PICU setting (**proposed**) 2. Consultants' clinical experience – symptomatic hypokalaemia is rare (**proposed**)

Paper	Condition	Key findings	Associated factors
Rhodes (2006)[30]	Diabetes	Based on intent to screen in the 3 vignettes, 21% of respondents reported American Diabetes Association-consistent screening practice, 39% screened also the low-risk patient, and 35% screened only the high-risk patient Many clinicians ordered screening tests other than those recommended by the American Diabetes Association; few (<9% in any vignette) ordered only an American Diabetes Association-recommended test	1. Inadequate patient education materials (47%), unclear recommendations for appropriate screening methods (45%), limited clinician time to provide appropriate counselling related to screening (42%), perception by patient or family that screening is unnecessary (40%) or anticipated non-compliance with screening or future treatment for type 2 diabetes were the most frequently reported moderate/strong barriers to screening (screening method needs to be practical for both clinicians and patients) (**actual**) 2. Preferences for non-fasting tests were influenced by non-medical factors such as access to or cost of transportation (**actual**)
Zoëga (2011)[14]	ADHD	Significant differences in total use of ADHD drugs between the Nordic countries, where relatively homogeneous populations, similar culture and national healthcare systems exist	1. Drug prescribing is a likely function of professional training and traditions of physicians and other mental health care providers. Several factors such as accessibility of drugs, available treatment alternatives, clinical practice and national guidelines, may influence the patterns of prescribing (**proposed**)

Appendix 11: Associated factors for variation in emergency department care

Paper	Condition	Key findings	Associated factors
Adams (2001)[25]	Asthma	Children aged 3–5 years were less likely to be dispensed any controller medication than older children ($p<0.001$) Among children dispensed 6 or more beta agonists, only 39% also received 5 or more controller dispensings, with adolescents significantly less likely than younger children to receive 5 or more controllers ($p<0.001$) Significant geographical variation in proportions of patients dispensed controller medication	1,2 and 3. Limited patient adherence because many children have both frequent dispensing of bronchodilators and one dispensing of controller but do not get refills of controller meds (**proposed**) 1, 2 and 3. Less frequent physician visits (unable to schedule routine and timely follow-ups to monitor clinical situation for children started on controller meds as recommended by guidelines) (**proposed**) 1, 2 and 3. External influences e.g. adolescents not being allowed to carry medication on their person while at school (**proposed**)
Babl (2008)[48]	Asthma	All sites recommended salbutamol and ipratropium, but delivery methods varied e.g. for severe to critical asthma – nebulised delivery of salbutamol preferred by 79% of doctors over metered dose inhalers. For critical asthma – IV aminophylline used by 45%, IV magnesium by 55% and IV salbutamol by 87%	Guidelines do not directly address the role of IV salbutamol vs other IV bronchodilators **(actual)**
Babl (2009)[33]	Status epilepticus	Variation in practice (medications used and route given, timing of intubation) for second/third-line management	No clear consensus on comparative effectiveness of second-line agents or on timing of intubation (**proposed**)
Bhatara (2007)[20]	ADHD medication	10% of all psychotropic visits were for atomoxetine vs 40% for stimulants. Use of atomoxetine varied by age (most preferred in 10–14 year olds), region and insurance status (more use in private)	1a. Patient and physician preferences (**proposed**) 1b. Possible better cost coverage of new medication leading to increased use in children privately insured (**proposed**)

Paper	Condition	Key findings	Associated factors
Bourgeois (2014)[49]	Asthma Bronchiolitis Pneumonia UTI Concussion/TBI	Greater than threefold variation in severity-adjusted admission rates for common paediatric conditions across hospitals Highest variation for concussion (range 5%–72%), followed by pneumonia (19%–69%) and bronchiolitis (19%–65%). The least variation was found among patients presenting with seizures (7%–37%) and kidney and urinary tract infections (6%–37%) Although variability existed in disease-specific admission rates, certain hospitals had consistently higher, and others consistently lower, admission rates	1, 2 and 3. Differences in hospital attributes. Differences in local and regional primary care systems (**proposed**) 1, 2 and 3. Differences in physician practice patterns – ED physicians appear to be strongly influenced by local standards of care as well as by personal attitudes towards risk tolerance and malpractice fear (**proposed**) 1, 2 and 3. Lack of appropriate guidelines in the ED focusing on admission requirements for specific illnesses and providing evidence-based criteria to support and standardise physician decision-making (**proposed**)
Goldman (2009)[50]	Fever	Variation in antipyretic use and IV fluids across centres % of antibiotics prescribed similar across centres but choice of antibiotics used varied Variation in tests ordered, especially lumbar punctures and X-rays	1, 2 and 3. No clearly endorsed guidelines (**proposed**) 1, 2 and 3. Difference in proportion of paediatric emergency medicine-trained physicians across sites. Such physicians are more likely to adhere to paediatric guidelines than those with general emergency medicine training (**proposed**)

Paper	Condition	Key findings	Associated factors
Isaacman (2001)[51]	Fever	Paediatric emergency medicine physicians ordered more complete blood counts (324/568 vs 27/81), more blood cultures (321/568 vs 27/81) and more urine cultures (208/568 vs 20/81) General emergency medicine physicians ordered more CXRs and cerebrospinal fluid analyses than paediatric emergency medicine physicians General emergency medicine physicians diagnosed more focal infections (109/228 vs 526/1323) General emergency medicine physicians conflicted more often with the practice guidelines (66/79 vs 225/498)	1. General emergency medicine physicians following adult-based care i.e. performing a urinalysis only and not confirming a suspected UTI with a urine culture (**proposed**) 1, 2, 3 and 4. Physician perspectives of: – disease prevalence – risk of not providing treatment – reliability of follow-up – concerns re: side effects of treatments **(proposed)** 1, 2, 3 and 4. Out-of-date guidelines **(proposed)**
Kelly (2003)[57]	Asthma	Underuse of corticosteroids in children with moderate or severe asthma Underuse of oxygen in severe asthma	1. Documentation errors i.e. steroids were given but not recorded **(proposed**) 2. Underclassification of severity compared with National Asthma Guidelines by treating doctor **(proposed**)
Kool (2014)[29]	Concussion/TBI	Variation in use of CT, written advice to parents and in decisions around referral for follow-up	1a. Lack of evidence about criteria for admission vs discharge in TBI **(proposed**) 1b. Lack of appropriate follow-up services as identified by providers (**actual**) 1c. More pressing priorities in the acute setting **(actual)**

Paper	Condition	Key findings	Associated factors
Langhan (2012)[45]	Analgesia & sedation	Large variation in frequency of use of each physiologic monitoring modality by healthcare provider type, medication used and procedure performed. Largest difference in monitoring use was seen between providers using electrocardiography (13%–95%) Adherence to CPGs published by the American Academy of Pediatrics, the American College of Emergency Physicians and the American Society of Anesthesiologists for non-anaesthesiologists was 52%	1. CPGs contain confusing language which is difficult to interpret (**proposed**) 2. Adherence to guideline-based monitoring may not reduce adverse events and not appropriate for certain settings (**proposed**)
Ochoa (2012)[55]	Bronchiolitis	64% of the treatments used in the acute phase and 55.9% in the treatment phase were considered inappropriate Variation in the use of all diagnostic tests e.g. CXR (13.6%–45.3%), CRP (0%–22.3%), RSV identification tests (0%–43.3%) Variation in the use of all treatments e.g. oral steroids (0%–44%), beta agonists (11.2%–85.2%) and antibiotics (3.9%–33.3%)	1. Use of inhaled bronchodilators in mild cases is the main cause of inappropriateness (**actual**) 1 and 3. Local prescribing habits reflect preferences of physicians **(proposed**)
Plint (2004)[22]	Bronchiolitis	73% of patients (range per site 59%–100%) were treated in the ED with bronchodilators (usually salbutamol or epinephrine) and 5% (range per site 0%–14%) with oral steroids Significant practice variation by site in ED bronchodilator use ($p<0.001$) and bronchodilator use at discharge ($p=0.0003$)	1. Small and conflicting RCTs in the area of bronchodilator use leading to conflicting advice (**proposed**) 2a. Evidence that bronchodilators may be beneficial for outpatients but not for inpatients (**proposed**) 2b. Possible clinician frustration attempting to treat this illness and thus using bronchodilators (**proposed**)

Paper	Condition	Key findings	Associated factors
Rice-Townsend (2014)[38]	Appendicitis	Significant variation found for all measures. 3.5-fold difference in pre-op imaging and fivefold difference in pre-op blood tests. Variation most marked in patients with complicated perforated appendicitis Costs of hospitalisation varied fourfold for uncomplicated and 4.6-fold for complicated appendicitis	1. Lack of high quality clinical data to inform care (**actual**) 2a. Lower socioeconomic status families may present later and require more intensive treatment (**proposed**) 2b. Children's hospitals may see younger patients with a higher rate of complications and treatment costs (**proposed**)
Schuh (2012)[58]	Asthma	Overall rate of comprehensive therapy was 382/654 (58%), which varied from 30%–84% ($p<0.0001$) Only 58% of patients without inhaled corticosteroids on arrival were offered inhaled corticosteroids at discharge. There was significant variation in the rates of all discharge pharmacotherapies across centres	1. Independent predictors of comprehensive therapy: daytime presentation (OR=1.67, 95% CI=1.05–2.67) and 'intensive stabilisation' (OR=2.33, 95% CI=1.29–2.67) **(actual)** 2. Clinicians may have relied on primary care providers to prescribe inhaled corticosteroids at follow-up (**proposed**)
Stanley (2007)[56]	Asthma	41% received any testing – 27% had a CXR, 14% had bloods (not blood gases) Variation in care by practitioner training i.e. children with asthma treated by emergency or paediatric physicians without paediatric ED training were more likely to undergo blood testing	1 and 2. Training – paediatric ED physicians see generally healthier patients than ED physicians without paediatric training so may not be as concerned and thus order fewer blood tests (**actual**)

Paper	Condition	Key findings	Associated factors
Uspal (2013)[24]	Analgesia & sedation	44% received procedural sedation. In those not sedated, 62% received topical local anaesthetic, 24% topical and injected local anaesthetic, 5% injected only and 8% nothing Younger patients and those with larger lesions were more likely to have procedural sedation. Physician experience and ED volumes did not affect variation	1 and 2. Individual training (**proposed**) 1 and 2. Lack of literature on pain management during incision and drainage (**proposed**) 1. Family preferences (**proposed**)
Widger (2009)[39]	Asthma	Dosage of medicines used via spacers and metered dose inhalers varied across sites Use of first-line IV bronchodilators varied i.e. 47% used IV salbutamol, 43% used IV aminophylline, 3% used magnesium	1 and 2. Lack of clarity around appropriate dosing for metred dose inhalers with some guidelines recommending based on age and others on asthma severity (**proposed**) 2. Lack of adequately powered head-to-head RCTs of IV bronchodilators (**proposed**)