Can Electronic Clinical Decision Support Systems Improve the Diagnosis of Urinary Tract Infections? A Systematic Review and Meta-Analysis

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Disclosures

- Elie Saade: Consultant Janssen
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Background

- Urinary tract infection (UTI) is a frequently misdiagnosed infectious syndrome
- Diagnostic stewardship interventions are useful but often resource intensive
- Previous studies have explored using clinical decision support (CDS) through EMR embedded tools to automate UTI diagnosis optimization
- We performed a systematic review and meta-analysis to determine the impact of clinical decision support on UTI diagnosis

Methods

Study Eligibility

Studies were eligible if they described an intervention utilizing CDS to improve diagnosis of UTI

CDS was defined as any EMR-based enhancement (algorithm or restricting orders) intended to increase accuracy of UTI diagnosis

Inclusion in meta-analysis required complete pre- and post-intervention urine culture data

Outcomes Explored in Studies

- Primary: Rate of urine culture orders
- Secondary
  - Rate of catheter-associated UTI
  - Guideline-concordant antimicrobial treatment and days of therapy
  - Antimicrobial-associated adverse outcomes
  - Adverse outcomes associated with missed diagnosis (CDI, mortality)
  - Cost savings
  - Provider acceptance

Search Strategy, Study Inclusion, and Quality Assessment

- Developed by an experienced medical librarian
- Electronic database search for peer-reviewed articles prior to July 2021
- Supplementary search using reference lists of full-text review articles
- Quality assessed using Joanna Briggs Institute critical appraisal checklist for quasi-experimental studies

Data Synthesis and Validation

- Qualitative description of intervention characteristics
- Meta-analysis data synthesis
  - Random effects model and inverse variance method used to combine incidence rates
  - Primary outcome expressed as
    - Incidence rate ratio (pre-intervention over post-intervention)
    - Incidence rate difference (post-intervention minus pre-intervention)
  - Heterogeneity of effects quantified with I^2 statistic

Results

PRISMA Diagram of Study Selection Process

Characteristics of Included Studies

First Author, Year	Study Type	Study Period Years	No. of Hospitals (unit type/ hospital type)	Intervention	Quality
Claeys, 2021	QE/ ITS	2013-2018	6 (inpatient)	Reflex urine culture	Fair
Coughlin, 2020	QE/ ITS	2015-2017	3 (ED; inpatient)	Reflex urine culture	Fair
Demonchy, 2014	QE/ treatment vs control vs treatment removal	2012	3 (ED)	Pop-up clinical guidelines	Fair
Epstein, 2016	QE/ ITS	2011-2013	1 (ICU)	Reflex urine culture	Fair
Eudaley, 2019	QE/ single group pre-post comparison	2017	1 (outpatient)	Test interpretation and treatment guidance	Poor
Howard-Anderson, 2020	QE/ ITS	2015-2018	3 (inpatient)	Reflex urine culture	Good
Keller, 2018	QE/ ITS	2014-2016	1 (inpatient)	Passive guidance	Poor
Lee, 2021	QE/ single group pre-post comparison	2018-2020	12 (inpatient; outpatient)	Reflex urine culture	Poor
Lynch, 2020	QE/ ITS	2016-2018	3 (inpatient; ED; LTC)	Reflex urine culture	Fair
Munigala, 2018	QE/ ITS	2015	1 (ED)	Reflex urine microscopy	Good
Munigala, 2019	QE/ ITS	2015-2017	1 (inpatient)	Reflex urine culture	Fair
Ourani, 2021	QE/ single group pre-post comparison	2020	1 (inpatient)	Reflex urine culture	Poor
Sarg, 2016	QE/ ITS	2012-2013	1 (ICU)	Reflex urine culture	Fair
Watson, 2020	QE/ ITS	2017-2019	5 (inpatient)	Reflex urine culture	Fair

*QE = Quasi-Experimental; ITS = Interrupted Time Series

Results for Primary Outcome of Urine Culture Rate

Author and Year	Pre-intervention	Post-intervention	% Change	P value
Claeys, 2021	35.8/1,000 PD	33.7/1,000 PD	-5.9	0.8
Coughlin, 2020	15.2/100 ED visits	9.3/100 ED visits	-38.8	NR
Epstein, 2016	NR	NR (decreased)	NR	<0.001
Eudaley, 2019	72% of visits for cystitis	40% of visits for cystitis	-44.4 (-32 absolute)	0.009
Howard-Anderson, 2020	35.2/1,000 PD	18.6/1,000 PD	-47.2	<0.001
Keller, 2018	18.2% of monthly admissions	11.8% of monthly admissions	-35.2 (-6.4 absolute)	<0.001
Lynch, 2020	3.6/100 PD	1.8/100 PD	-50	<0.001
Munigala, 2018	54.3/1,000 ED visits	29.7/1,000 ED visits	-45.3	<0.001
Munigala, 2019	38.1/1,000 PD	20.9/1,000 PD	-45.1	<0.001
Ourani, 2021	NR	24.6% of total urine samples	NR	NR
Sarg, 2016	139/1,000 PD	93/1,000 PD	-33.1	NR
Watson, 2020	1,175.8/10,000 PD	701.4/10,000	-40.3	<0.01

*PD = Patient Days; ED = Emergency Department; NR = Not Reported

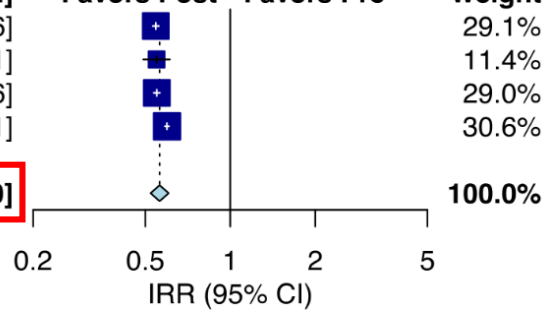
Meta-Analysis Results

- 4 studies met inclusion criteria – all utilized a reflex urine culture approach
- Percent change (%) in urine culture rate ranged from -40.4 to -45.6 in individual studies
- Incidence rate ratio of 0.56 (95% CI 0.52, 0.60)
- Incidence rate difference per 1,000 person-days of 24.12 (95% CI -48.92, 0.68)
- Uniformity in degree of change confers some confidence, but there is high heterogeneity among the included studies

Incidence Rate Ratio

Source	p–y Post Events	p–y Post Time	p–y Pre Events	p–y Pre Time	IRR [95%–CI]	Weight
Howard–Anderson 2020	7585	1113.10	24511	1957.70	0.54 [0.53; 0.56]	29.1%
Lynch 2020	507	70.80	894	68.40	0.55 [0.49; 0.61]	11.4%
Munigala 2019	8823	1154.60	15746	1131.10	0.55 [0.53; 0.56]	29.0%
Watson 2020	20064	783.20	32598	759.00	0.60 [0.59; 0.61]	30.6%
Random effects model	**36979**		**73749**		**0.56 [0.52; 0.60]**	**100.0%**

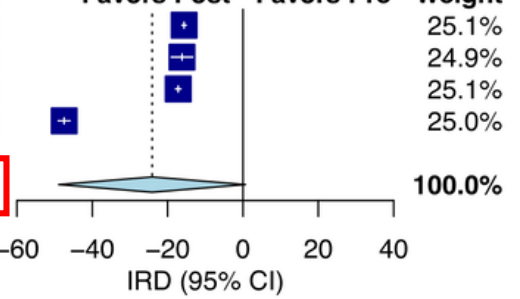
Heterogeneity: $I^2 = 94\%$, $\tau^2 = 0.0017$, $p < 0.01$



Incidence Rate Difference per 1,000 Person-Days

Source	tpdPost Events	tpdPost Time	tpdPre Events	tpdPre Time	IRD [95%–CI]	Weight
Howard–Anderson 2020	7585	406.60	24511	715.10	−15.62 [−16.22; −15.02]	25.1%
Lynch 2020	507	25.90	894	25.00	−16.18 [−19.08; −13.29]	24.9%
Munigala 2019	8823	421.70	15746	413.10	−17.19 [−17.93; −16.46]	25.1%
Watson 2020	20064	286.10	32598	277.20	−47.47 [−49.07; −45.86]	25.0%
Random effects model	**36979**		**73749**		**−24.12 [−48.92; 0.68]**	**100.0%**

Heterogeneity: $I^2 = 100\%$, $\tau^2 = 242.1199$, $p < 0.01$



Notable Differences Between Meta-Analysis Studies

Characteristic	Howard-Anderson	Lynch	Munigala, 2019	Watson
Pre- /Post- urine culture rate per 1,000 patient days	35.2 / 18.6	35.8 / 18.2	38.1 / 20.9	117.6 / 70.1
Urine reflex criteria	≥ 10 WBCs	> 10 WBCs	Any positive leukocyte esterase or nitrites	≥ 10 WBCs
Intervention mandatory	Provider override/ dismissal option	No exceptions	Provider override/ dismissal option	No exceptions
ED patients	Excluded	Excluded	Excluded	Not excluded
Number of hospitals	3	1	1	5
Hospital type	1 academic; 1 community; 1 mixed	VHA	Academic	4 community; 1 academic
Study location	Georgia	Maryland	Missouri	Texas

Selected Additional Outcomes – Explored by Very Few Studies

- Marginal effect on CAUTI rate (n = 2 studies)
- Improvement in various measures of antimicrobial use (days of therapy and guideline concordance) – all 7 studies showed improvements post-intervention
- Estimated annual savings between $11K and $500K (n= 4 studies)
- Provider utilization between 30% and 60% (n = 2 studies)
- No difference in *C. difficile* infections, resistance development, bloodstream infection, or mortality rate

Limitations

- Few high quality studies
- Only 4 out of 14 studies met criteria for meta-analysis
- Significant heterogeneity between studies
- Secondary outcomes insufficiently studied

Conclusions

- Clinical decision support was associated with generally lower urine culture rates in the systematic review and 40% lower rate in the meta-analysis
- Downstream impact of decreased urine culture rate not sufficiently studied
- Future prospective trials should evaluate CDS and urine culture diagnostic stewardship in context of patient-relevant outcomes

Thank You

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