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Exploring the Role of Infographics for Summarizing Medical Literature

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Abstract

Purpose: To investigate differences in (1) reader preference, (2) cognitive load during summary review, and (3) delayed information retention between infographic article summaries and traditional text-only research abstracts.
Methods: The three study outcomes were assessed using a two-phase within-subjects experiment. In phase 1, participants rated cognitive load as the mental effort they invested in reviewing eight article summaries (four in infographic format and four in text-only abstract format) on the 9-point Paas scale (1 = low mental effort, 9 = high mental effort) and indicated their preferred summary format on a 9-point preference scale (1 = preferred infographics, 9 = preferred text-only abstracts). Four weeks later, phase-2 tested delayed information retention via two free-recall and two cued-recall questions per article.
Results: Participants preferred infographic summaries to traditional text-only research abstract summaries as evidenced by a mean format preference score (mean ± standard deviation) of 3.97 ± 2.48 ($t(71) = 13.6$, $p = 0.01$) which was significantly more positive than the neutral score of 5 on the 9 point preference scale. Mean mental effort during summary review was lower for infographics (4.30 ± 1.34) than for text-only abstracts (5.06 ± 1.35, $t(70) = 4.41$, $p = 0.01$). There was no statistically significant difference in delayed information retention.
Discussion: This study suggests that infographics could play a role in summarizing medical research literature. While no difference was found in delayed information retention, infographics were associated with higher reader preference and lower cognitive load during summary review. Further research should clarify the practical implications of these findings.

Keywords: Infographics; Information retention; Cognitive load; Dual-coding theory

1. Introduction

Evidence-based medicine has been defined as a combination of clinical judgment, patient values and preferences, and relevant scientific evidence[1] and is a

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cornerstone of modern medical practice.[2] To provide evidence-based care, healthcare professionals must stay up-to-date with medical literature relevant to their practices. However, barriers including an ever-expanding volume of published literature,[3,4] time constraints,[5] and difficulty retaining information[6,7] impact their knowledge of published scientific evidence and the incorporation of evidence into clinical care. In an effort to mitigate these barriers, medical journals, manuscript authors, medical educators and open-access medical education websites have begun using social media and multimedia tools such as Twitter,[8–11] Facebook,[10,12,] blogs, podcasts[10,11,13,14] and infographics[14,15] to increase healthcare professionals' exposure to, and knowledge of, new publications.

Infographics are "visualizations of data and ideas that try to convey complex information to an audience in a manner that can be quickly consumed and easily understood."[16] They are becoming more prevalent as a tool for summarizing and disseminating medical literature in both the online and print journal settings.[14,15] However, there is limited research assessing their effectiveness. Previous studies have assessed whether healthcare professionals prefer infographics to text-only formats[17,18] and evaluated their impact on increasing online dissemination.[14] However, Cognitive Load Theory and Dual-Coding Theory suggest that infographics could address one of the barriers limiting the integration of evidence-based medicine into clinical practice by increasing information retention.[6,7]

Cognitive Load Theory is based on the principle that working memory has finite capacity.[19] As such, the brief statements and images found in infographics could potentially be easier for working memory to process which could lead to improved information retention. Additionally, Dual-Coding Theory suggests that graphics are more likely to be encoded as both verbal and visual traces in long-term memory and therefore, the image components of infographics could allow for enhanced retention and improved information retrieval.[20] Although these theoretical advantages suggest that infographics may lead to improved information retention amongst healthcare professionals, there are also potential disadvantages to the use of infographics that should be taken into consideration. From a theoretical perspective, research has suggested that adding illustrations to text can potentially hinder the learning process if images are redundant or purely aesthetic.[21] Furthermore, from the practical standpoint, infographics also require time, effort and money to create and publish.

Given the lack of literature to guide the use of infographics as a format for presenting medical literature to healthcare professionals, this study was developed to assess both subjective and objective markers of infographic utility in this context. More specifically, this study sought to evaluate whether reader preference, cognitive load during summary review and delayed information differed between infographic article summaries and "traditional" text-only research abstracts among a group of Canadian Emergency Medicine Physicians. Based on the theoretical principles underpinning infographics, we hypothesized that (1) Emergency Physicians would prefer infographic summaries to text-only abstract article summaries; (2) infographic article summaries would be associated with lower cognitive load scores during summary review compared to text-only abstract article summaries; and (3) infographic articles summaries would lead to higher delayed information retention scores compared to text-only abstract article summaries.

2. Methods

2.1. Overview

We conducted a two-phase within-subjects experiment to assess reader preference, perceived mental effort during summary review, and delayed information retention at four weeks between infographic and text-only abstracts. The study population consisted of a sample of Canadian Emergency Medicine Physicians. A within-subjects study design was selected to control for individuals' variability in information retention (i.e. each participant served as his or her own control). Four-week retention was selected as an outcome of interest as it has been cited in previous educational retention studies[22,23] and it was feasible within our study design.

2.2. Participants

The included articles were published in the *Canadian Journal of Emergency Medicine.* Therefore, Canadian Emergency Medicine Physicians were the population of interest for this study. To facilitate the recruitment process, a convenience sample of 112 Emergency Physicians working in the primary study author's home province of Saskatchewan and meeting the inclusion criteria were invited to participate. The inclusion criteria included: (a) the participant is a staff physician working call shifts or a physician in a casual, part-time

or full-time clinical position in a rural, regional or urban emergency department in the province of Saskatchewan, or (b) the participant is a resident physician currently enrolled in an Emergency Medicine residency program (specialty or enhanced-skills) or Family medicine residency training program requiring emergency department call coverage in the province of Saskatchewan. Participants meeting the exclusion criteria (the participant is a member of the study team and/or the participant was involved in one of the study's pilot phases) did not participate.

2.3. Materials

2.3.1. Infographics

Members of the study team collaborated with the *Canadian Journal of Emergency Medicine (CJEM)* social media promotion team to select the articles and create the infographics. Eight "original research" articles published in the *CJEM* from July 2015 to November 2016 that were deemed to be relevant to Canadian Emergency Medicine were included in the study. SH created infographics for each of the eight articles using Piktochart software.[24] Four principles for reducing extraneous processing (processing that does not contribute to understanding or learning): coherence, signaling, redundancy and spatial contiguity,[25] as well as two best practice tips for infographic design (compellingness and coherence)[26] informed the infographic design process. Infographics were reviewed by members of the *CJEM* social media promotion team which consisted of CJEM editors, staff Emergency Medicine Physicians, resident physicians and medical students—and, when time permitted, by each article's authors.[14] Appendix A contains a sample infographic.

2.3.2. Text-only abstracts

The text-only abstracts used in this study were obtained from the *CJEM*. A screen capture of each article's abstract was obtained and extraneous material (French language translation or material from the article's main text visible in the screen capture) was removed so that only the title, author information and English abstract text were present. Appendix A contains a sample text-only abstract.

(1) Very very low mental effort (Driving a car)
(2)
(3)
(4)
(5) Neither high nor low mental effort
(6)
(7)
(8)
(9) Very very high mental effort (Writing an exam)

Fig. 1. The Paas Mental Effort Scale[28].

2.3.3. Survey

The survey used in phase-1 was developed using Qualtrics survey software.[27] It consisted of a demographic questionnaire, four infographic and four text-only summaries for review, four questions pertaining to each of the article summaries (i.e. participants were asked about their familiarity with each article, each article's relevance to, and potential impact on, their practice and to provide a Paas rating (validated tool for measuring mental effort—see Fig. 1)[28] to assess the mental effort invested in reviewing each summary) and a final question requiring participants to rank their preferred article summary format on a 9-point scale (1-preferred infographics; 5-neutral preference; 9-preferred text-only abstracts).

2.3.4. Retention test

The retention test used in phase-2 of the study was also designed using Qualtrics survey software.[27] This retention test verified whether participants had reviewed any of the text-only abstracts, infographics or corresponding articles between the two study phases and assessed participants' delayed information retention via two free-recall questions and two true-or-false questions pertaining to each article summary's primary objective and primary conclusion/finding. Appendix A contains a sample of free-recall and cued-recall questions.

2.3.5. Answer key and rating tool

A rating tool for assessing free-recall retention test questions was developed using the concept of idea units[29] (i.e. the 'ideal answer' for each question was determined by the study group and a rating tool assigning points to each of the sub-components (idea units) of the 'ideal answer' was devised). A 'single correct response' answer key was developed for marking cued-recall retention question responses. Appendix A provides an example of the free-recall and cued-recall answer keys.

2.4. Procedures

Prior to study commencement, the phase-1 survey and the phase-2 retention tests were piloted by the study authors and a group of staff and resident Emergency

Table 1
Infographic and text-only abstract counterbalancing conditions.

Article #	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5	Condition 6	Condition 7	Condition 8
1	infographic	text-only	text-only	infographic	infographic	text-only	infographic	text-only
2	infographic	text-only	text-only	infographic	text-only	infographic	text-only	infographic
3	infographic	text-only	infographic	text-only	text-only	infographic	infographic	text-only
4	infographic	text-only	infographic	text-only	infographic	text-only	text-only	infographic
5	text-only	infographic	infographic	text-only	infographic	text-only	infographic	text-only
6	text-only	infographic	infographic	text-only	text-only	infographic	text-only	Infographic
7	text-only	infographic	text-only	infographic	text-only	infographic	infographic	text-only
8	text-only	infographic	text-only	infographic	infographic	text-only	text-only	infographic

Table 2
Infographic and text-only abstract counterbalancing results.

Article summary	Phase-1		Phase-2	
	Infographic %	Text-Only %	Infographic %	Text-Only %
#1	48.6	51.4	50.8	49.2
#2	50.0	50.0	49.2	50.8
#3	51.4	48.6	49.2	50.8
#4	50.0	50.0	47.5	52.5
#5	50.0	50.0	50.8	49.2
#6	51.4	48.6	49.2	50.8
#7	50.0	50.0	52.5	47.5
#8	48.6	51.4	50.8	49.2

Medicine Physicians. The pilots resulted in edits for content and correction of technological issues.

A study team member who did not have a working relationship with the study participants (BG) disseminated the phase-1 survey and phase-2 retention test and collected the data. The survey and retention tests were e-mailed to potential participants on January 12th (day 1) and February 9th, 2017 (day 29). Participants were given seven days to complete each survey/test and were required to complete each survey/test in one attempt.

2.4.1. Survey

After collecting demographic information, participants were presented the infographic and text-only article summaries for review. Article summaries were presented in series and participants were required to review each article summary for a minimum of one minute and a maximum of three minutes before answering the four questions pertaining to each summary. A counterbalancing strategy (Table 1) was used to ensure that each article summary was reviewed in each of the formats (infographic and text-only) by roughly half the study population. Counterbalancing was accomplished by consecutively assigning participants to one of eight conditions when adding their email addresses for distribution. Additionally, the order in which article summaries were presented to each participant was randomized by the Qualtrics survey software[27] to minimize order effect bias.

2.4.2. Retention test

The retention test was divided into two subsections: a) cued-recall and b) free recall. Participants were required to complete all free-recall questions before accessing the cued-recall questions to ensure that cued-recall questions did not influence free-recall responses. Cued-recall questions were marked according to the 'single correct response' answer key, which resulted in an infographic cued-recall score out of eight possible marks and a text-only abstract cued-recall score out of eight possible marks for each participant. Free-recall responses were rated separately by two members of the study team (LM & AT) using the 'idea unit-based' answer key. Each free-recall question/response was marked out of a score of eight possible marks by each rater. Subsequently, the average free-recall score for each question/response was determined by averaging the two raters' scores. Infographic and text-only abstract response scores were tallied to yield a final infographic free-recall score (out of 64 possible marks) and a text-only abstract free-recall score (out of 64 possible marks) for each participant.

2.5. Data analysis

All statistical analyses were conducted using IBM SPSS version 24.0.[30] Paired-samples *t*-tests assessed for a difference in mean perceived mental effort scores, free-recall scores, and cued-recall scores between infographics and text-only abstracts. A one-sample t-test was used to determine whether the mean format preference score differed from the neutral preference scale value of five. Cohen's *d* was calculated to assess

Table 3
Subject demographics and demographic descriptive statistics.

	Completed Phase-1 Survey N (Percent)	Completed Phase-1 & Phase-2 Surveys N (Percent)
Number of subjects	72	61
Age (years)		
20–30	15 (21)	14 (23)
31–40	34 (47)	26 (42)
41–50	19 (26)	17 (28)
51–60	3 (4)	3 (5)
≥ 61	1 (1)	1 (2)
Gender		
Male	52 (72)	45 (74)
Female	20 (28)	16 (26)
Position		
Staff	58 (82)	51 (84)
Resident	13 (18)	10 (16)
VSP Staff credentials	*N*=58	*N*=51
CCFP	14 (24)	14 (23)
CCFP-EM	39 (67)	33 (54)
FRCPC	5 (9	4 (7)
Staff time in practice		
< 1 Year	8 (14)	7 (12)
1–5 Years	17 (29)	14 (23)
6–10 Years	16 (28)	15 (25)
> 10 Years	17 (29)	15 (25)
Resident training program		
Royal College Emergency Medicine	9 (69)	7 (12)
Family Medicine Emergency Medicine	4 (31)	3 (5)
Practice location		
Rural (< 10,000)	6 (8)	6 (10)
Regional (10,000-100,000)	7 (10)	6 (10)
Urban (> 100,000)	59 (82)	49 (80)
Frequency of social media Use		
Daily	22 (31)	17 (28)
≥ Once Per Week	26 (36)	25 (41)
≥ Once Per Month	11 (15)	7 (11)
< Once Per Month	9 (12)	8 (13)
< Once Per Year	4 (6)	4 (7)
Preferred format-literature Review		
Print Journals	2 (3)	2 (3)
Tablet/Smartphone	38 (53)	31(52)
Computer	31 (44)	27 (45)

effect sizes of format preference, perceived mental effort and cued- and free-recall results with Cohen's *d* values of 0.2, 0.5 and 0.8 indicating small, medium and large effects respectively.[31]

3. Results

Of the 112 emergency physicians invited to participate in this study, 72 completed the phase-1 survey, and 61 completed both the phase-1 and phase-2 surveys with a mean time delay between phases of 29 days. Infographic and text-only abstract format exposure was similar for each of the eight article summaries (Table 2).

Most respondents were male (72%) staff physicians (81%) between the ages of 31–40 (47%) who practice in urban emergency departments (82%). This is similar to the national statistics published by the Canadian Medical Association which found that 72% of the 844 Emergency Physicians surveyed in 2016 were male, 33% were between the age of 35–45 and 12% were less than 35.[32] Complete participant demographic results are reported in Table 3.

There were no obvious demographic differences between the participants who completed phase-1 only and those who completed both phases. As such, the analyses of preference and cognitive load were conducted with data from the 72 phase-1 respondents. Analyses on information retention were conducted with data from the 61 phase-1 and phase-2 respondents.

Participants had a preference for infographics with a small-moderate effect size (Fig. 2).The mean preference score of 3.97 ± 2.48 was significantly different than the neutral score of 5 ($t(71)=13.6$, $p < 0.01$, $d=0.42$) on a 1–10 scale, with 1 signifying strong preference for infographics and 10 signifying strong preference for text-only abstracts.

Perceived mental effort measured on the 9-point Paas scale[28] was significantly lower when participants viewed infographics (4.30 ± 1.34) than when they viewed text-only abstracts (5.06 ± 1.35, $t(71)=4.41$, $p < 0.01$, $d=0.57$) with a moderate-large effect size.

There was no significant difference in free-recall between text-only abstract (12.55 ± 14.01) and infographic (14.12 ± 14.68) groups ($t(60)=-0.82$, $p=0.21$, $d=0.11$) or in cued-recall between text-only abstract (59.63 ± 17.62) and infographic (55.94 ± 17.62) groups ($t(60)=1.05$, $p=0.15$, $d=0.21$).

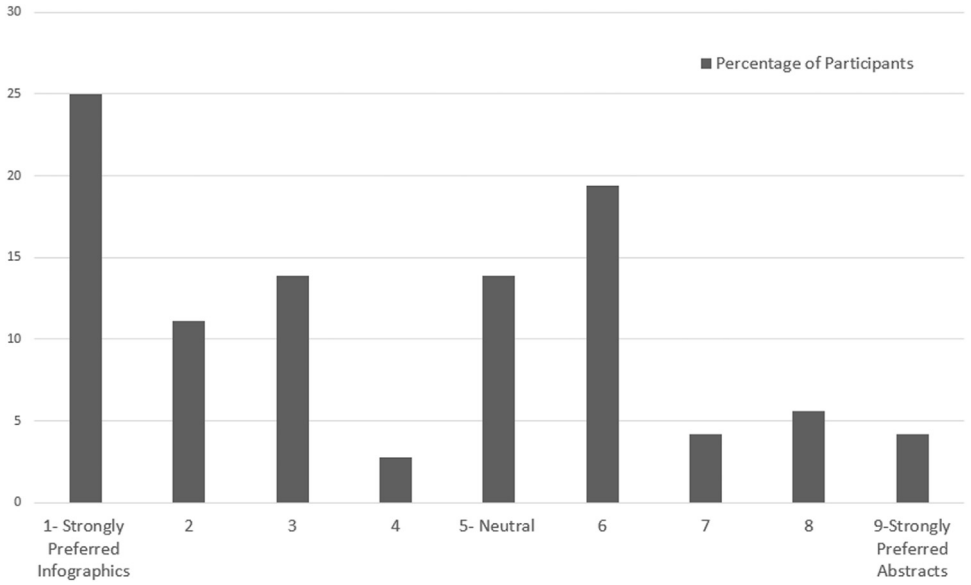

Fig. 2. Participant format preference.

4. Discussion

This study provides insights into the use of infographics for summarizing medical literature. In keeping with previous literature, we found that infographics were preferred to text-only article summaries.[17] Our hypothesis that reviewing article summaries in infographic format would be associated with lower cognitive load scores than reviewing articles in text-only abstract format was supported. These results suggest that infographics could play a role in summarizing medical literature since healthcare professionals prefer infographics to text-only abstracts, find them less mentally taxing to review, and as a result may be more inclined to review infographics than abstracts to improve their knowledge of new literature.

Contrary to our hypothesis that infographics would result in greater delayed information retention than text-only abstracts, both formats resulted in similar delayed information retention. This suggests that infographics could be a reasonable alternative to traditional text-only research abstracts for providing healthcare professionals with brief literature summaries. Unfortunately, delayed retention scores were poor in both formats. Retention may have been better had the testing interval been less than four weeks or had the participants been primed regarding the nature of phase-2. Future research should focus on more effective ways to summarize and present literature to busy healthcare professionals.

Our study had several limitations. First, all infographics used in this study were made by an experienced infographic designer and edited by a team of experienced physician editors. As such, our results are not generalizable to infographics that are not created with the same methodological rigor. Second, we only studied a population of Canadian Emergency Medicine Physicians. It is unclear whether the same results would be seen in other physician and non-physician healthcare professionals. Third, a convenience sample of Emergency Medicine Physicians was used and these physicians may have reviewed the presented information in a passive and rushed manner. While this passive and rushed review manner likely reflects time constraints inherent to daily practice, it is unclear whether the results would differ if participants reviewed these articles more actively. Fourth, we investigated our format preference and information retention outcomes of interest with tools that had no validity evidence. As a result, this study's results could be limited by validity concerns inherent to these measures. Finally, we included author information in the text-only abstracts to adhere to the visual format of the original content. While this increases the generalizability of the results as the summaries were presented as they would be reviewed in the real world, there is potential that this could bias the results in an

undetermined direction for summaries of research published by authors known to the participants.

In summary, our study suggests that infographics could play a role as a medium for summarizing medical research literature. While we found no difference in delayed information retention between infographics and traditional text-only research abstracts, infographics were preferred by readers, lowered readers' cognitive load, and did not worsen retention.

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Ethical approval

Ethical approval has been granted from the University of Saskatchewan Behavioral Research Ethics Board (16 November 2016, BEH 16–047).

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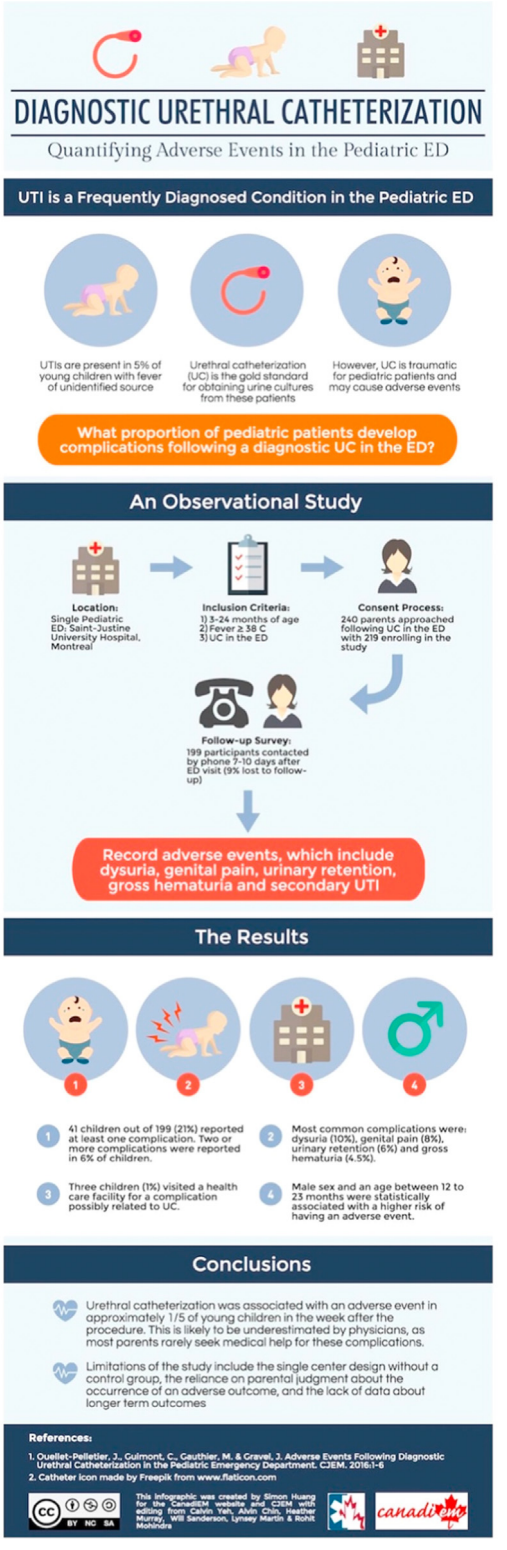
None.

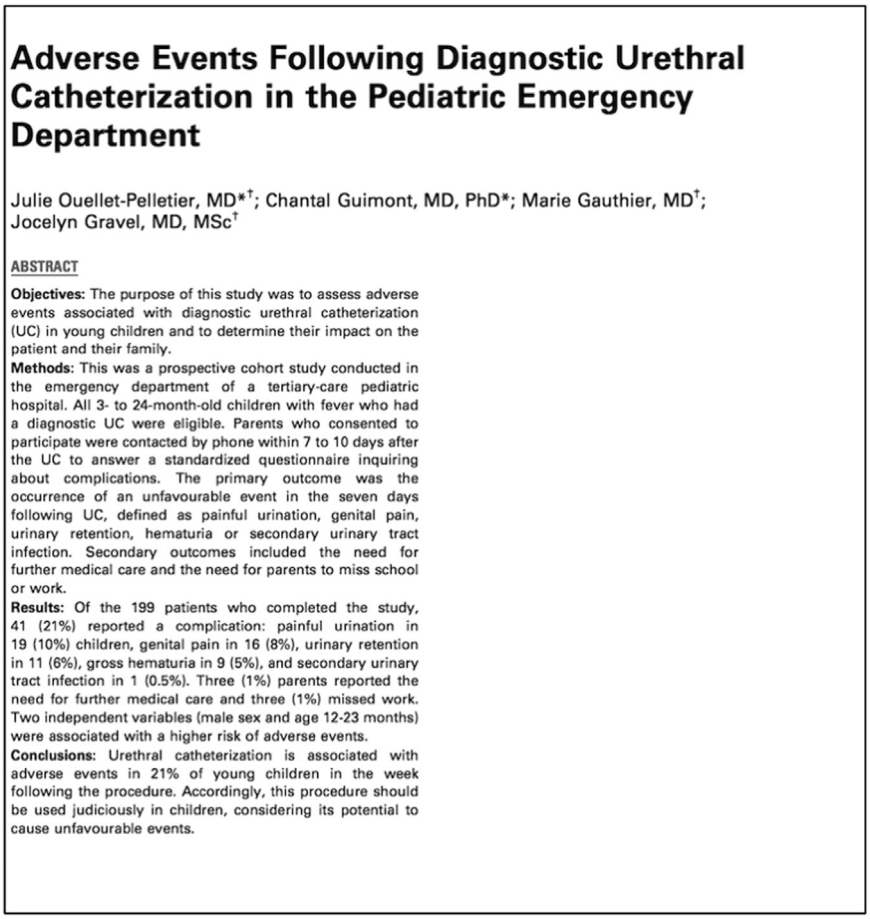
Other disclosure

None.

Appendix A

Sample article summaries, post-test information retention questions and answer keys.





Adverse Events Following Diagnostic Urethral Catheterization in the Pediatric Emergency Department

Julie Ouellet-Pelletier, MD*†; Chantal Guimont, MD, PhD*; Marie Gauthier, MD†; Jocelyn Gravel, MD, MSc†

ABSTRACT

Objectives: The purpose of this study was to assess adverse events associated with diagnostic urethral catheterization (UC) in young children and to determine their impact on the patient and their family.

Methods: This was a prospective cohort study conducted in the emergency department of a tertiary-care pediatric hospital. All 3- to 24-month-old children with fever who had a diagnostic UC were eligible. Parents who consented to participate were contacted by phone within 7 to 10 days after the UC to answer a standardized questionnaire inquiring about complications. The primary outcome was the occurrence of an unfavourable event in the seven days following UC, defined as painful urination, genital pain, urinary retention, hematuria or secondary urinary tract infection. Secondary outcomes included the need for further medical care and the need for parents to miss school or work.

Results: Of the 199 patients who completed the study, 41 (21%) reported a complication: painful urination in 19 (10%) children, genital pain in 16 (8%), urinary retention in 11 (6%), gross hematuria in 9 (5%), and secondary urinary tract infection in 1 (0.5%). Three (1%) parents reported the need for further medical care and three (1%) missed work. Two independent variables (male sex and age 12-23 months) were associated with a higher risk of adverse events.

Conclusions: Urethral catheterization is associated with adverse events in 21% of young children in the week following the procedure. Accordingly, this procedure should be used judiciously in children, considering its potential to cause unfavourable events.

Free-recall questions.

You reviewed an article summary related to: urinary catheterization

1) What was this study's primary objective? (Please answer this question to the best of your abilities by providing as much detail as possible. E.g. study population, intervention, controls and primary outcome of interest. If you cannot remember the study's primary objective, you may leave the text-field blank.)
2) What was the study's primary conclusion/finding? (Please provide as much detail as possible. If you cannot remember this study's primary conclusion/finding, you may leave this text-field blank.)

Cued-recall questions

1) You reviewed an article summary related to: urinary catheterization. This study's primary objective was to: determine the risk of adverse events following diagnostic urethral catheterizations in the emergency department among pediatric patients age 3-24 months.
   a) True
   b) False
2) You reviewed an article summary related to: urinary catheterization. This study's primary conclusion/finding was: emergency department diagnostic urethral catheterization is associated with complications in 21% of 3-24 month-olds in the week following the procedure.
   a) True
   b) False

Free-recall answer key

1) Risk (1pt) of adverse events/complications (1 pt); diagnostic urethral catheterization (2 pt); febrile (2 pt) and pediatric patients (1pt) OR patients age 3-24 months (2pts)* need to have 3-24 months to get full two points
2) Diagnostic (1pt) urethral catheterization (1pt) is associated with adverse events/complications (1pt)

in approx. 1/5 or 21% (2pts) of pediatric patients (1pt) OR (pediatric) patients age 3-24 months (2pts) * need to have 3-24 months to get full 2 points in the 1 week following the procedure (1pts).

Cued-recall answer key

1) True (1 point); False (0 points)
2) True (1 point); False (0 points)

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