Cost-effectiveness of preferred fluids versus electrolytes in pediatric gastroenteritis

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Abstract

Background While electrolyte maintenance solution is recommended and commonly used in pediatric gastroenteritis, it can be more costly and less palatable than preferred fluids such as apple juice.

Objective To assess the incremental cost-effectiveness of apple juice/preferred fluids versus electrolyte maintenance solution in reducing treatment failures in children in an emergency department from societal and health care perspectives.

Methods A probabilistic cost-effectiveness analysis was performed using clinical trial and chart data. All intervention, and direct and indirect costs were included, with a 14-day time horizon. Cost-effectiveness was examined by calculating the difference in mean number of treatment failures and mean cost/patient between treatment groups. The probabilistic point estimate and 95% confidence intervals for incremental costs and incremental effectiveness were determined.

Results The apple juice strategy was less costly than electrolytes with average per child savings of CAD \$171 (95% CI \$22 to \$1097) from a societal perspective, and \$147 (95% CI \$23 to \$1056) from a health care perspective. There were 0.08 fewer treatment failures per child (95% CI – 0.15 to – 0.02). The higher electrolyte maintenance solution cost was due to more frequent hospitalizations, ongoing care, and greater lost parental productivity due to additional medical visits.

Conclusion Apple juice/preferred fluids strategy was dominant over electrolytes in the treatment of children with minimal dehydration secondary to acute gastroenteritis as this option yielded fewer treatment failures and a lower societal cost. Given the high prevalence of acute gastroenteritis, this approach may result in significant cost savings while leading to improved clinical outcomes.

Keywords Gastroenteritis · Child health · Oral rehydration therapy · Cost-effectiveness analysis

Résumé

Contexte Bien que la solution de maintien des électrolytes soit recommandée et couramment utilisée dans les gastro-entérites pédiatriques, elle peut être plus coûteuse et moins agréable au goût que les liquides préférés tels que le jus de pomme.

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Objectif Évaluer le rapport coût-efficacité supplémentaire du jus de pomme/des liquides préférés par rapport à des électrolytes pour réduire les échecs de traitement chez les enfants dans un service d'urgence, du point de vue de la société et des soins de santé.

Les méthodes Une analyse probabiliste de la rentabilité a été réalisée en utilisant les données des essais cliniques et des dossiers. Tous les coûts d'intervention, directs et indirects, ont été inclus, avec un horizon temporel de 14 jours. La rentabilité a été examinée en calculant la différence du nombre moyen d'échecs de traitement et du coût/patient moyen entre les groupes de traitement. L'estimation ponctuelle probabiliste et les intervalles de confiance à 95% pour les coûts différentiels et l'efficacité différentielle ont été déterminés.

Résultats La stratégie du jus de pomme était moins coûteuse que les électrolytes, avec des économies moyennes par enfant de 171 \$ CAD (IC à 95 % : 22 \$ à 1097 \$) du point de vue sociétal et de 147 \$ (IC à 95 % : 23 \$ à 1056 \$) du point de vue des soins de santé. Il y a eu 0,08 échec de traitement en moins par enfant (IC 95 % : -0,15 à -0,02). Le coût plus élevé des électrolytes est dû à des hospitalisations plus fréquentes, à des soins continus et à une plus grande perte de productivité des parents en raison de visites médicales supplémentaires.

Conclusion La stratégie du jus de pomme/des liquides préférés a été dominante sur les électrolytes dans le traitement des enfants présentant une déshydratation minimale secondaire à une gastro-entérite aiguë, car cette option a permis de réduire les échecs du traitement et le coût pour la société. Compte tenu de la prévalence élevée de la gastro-entérite aiguë, cette approche peut entraîner des économies de coûts significatives tout en améliorant les résultats cliniques.

Clinician's capsule

What is known about the topic?

Recommended rehydration for gastroenteritis has been electrolyte solution, but it is costly, lacks palatability, and leads to overuse of intravenous rehydration.

What did this study ask?

What is the cost-effectiveness of preferred fluids compared to electrolyte maintenance solution in mild pediatric gastroenteritis presenting to the emergency department?

What did this study find?

Preferred fluids resulted in an incremental savings of \$171 CAD per child and resulted in fewer treatment failures.

Why does this study matter to clinicians?

Routine administration of preferred fluids is associated with better clinical outcomes and savings to institutions and society.

frequent. Within the United States, approximately 1.5 million outpatient visits and 200,000 hospitalizations occur due to acute pediatric gastroenteritis [1, 2], with significant cost implications. The total U.S. hospital costs for gastroenteritis care in children have been estimated at \$150 million [3]. Hospitalization and prevalence data for pediatric gastroenteritis are not available for the Canadian population.

Most children with gastroenteritis who present to the ED are at most mildly dehydrated and, thus, candidates for oral rehydration therapy. The recommended rehydration strategy in high-income countries has been electrolyte maintenance solution [1] due to its high sodium-to-glucose ratio. However, this solution lacks palatability [4], leading to refusal and poor compliance and ultimately to excessive administration of intravenous rehydration [5–7]. An alternative therapy may be apple juice or other fluids preferred by children as better compliance may lead to improved outcomes. Moreover, as these preferred fluids are more readily available at lower cost per litre compared to the electrolytes [5, 8], their use may generate savings and demonstrate cost-effectiveness. Given the high prevalence of pediatric gastroenteritis and healthcare budget constraints, this knowledge would inform practice to optimize and decrease the cost of care of this common disease.

In a previously conducted randomized-controlled trial [7], investigators randomized 647 children who presented to the ED of a tertiary pediatric hospital with acute gastroenteritis to receive either half-strength apple juice in the ED plus preferred fluids after discharge or electrolytes. All children were followed for 14 days from enrollment. Among these children, there were fewer treatment failures in the apple juice group compared to the electrolytes group (16.7% vs. 25.0%, respectively; $p < 0.001$). The objective of this

Introduction

Constrained healthcare budgets struggle to meet the increasing demand for health care services. The largest proportion of healthcare utilization is consumed by patients representing a small number of common conditions, such as pediatric gastroenteritis, where emergency department (ED) visits are

cost-effectiveness analysis was to examine the incremental cost of the apple juice/preferred fluids' strategy compared to the electrolytes approach per treatment failure averted in children with gastroenteritis from a societal and health care payer perspective.

Methods

A cost-effectiveness analysis comparing apple juice/preferred fluids to electrolyte maintenance solution for children aged 6–60 months with gastroenteritis and minimal-to-mild dehydration presenting to the ED was performed. This evaluation was based on patient-level data obtained in the previous trial [7]. Details of this trial (clinicaltrials.gov identifier: NCT01185054) have been published [7]. This cost-effectiveness analysis was approved by the Research Ethics Board of The Hospital for Sick Children and parents of participants provided informed consent. This work is conducted in keeping with guidelines set out by the Canadian Agency for Drugs and Technologies in Health [9] as well as standard methods in economic evaluation [10, 11].

Design

Decision analysis was used to perform a probabilistic cost-effectiveness analysis from societal and health care payer perspectives. The analysis compared administering apple juice in the ED followed by preferred fluids at home after discharge to the use of electrolytes in averting treatment failures among children with none-to-minimal dehydration secondary to acute gastroenteritis. Because of the importance of reflecting parent productivity losses in pediatric settings [12], the societal perspective was the reference case. The decision model was informed by the actual cohort of patients in the trial presenting to the ED for treatment. A 'no treatment' option was not included as all patients were treated. The time horizon spanned the follow-up interval in the clinical trial from enrollment in the ED to 14 days after enrollment. Given the mild nature of the condition, no long-term sequelae were anticipated. Treatment failure was defined by any of the following occurring in the 7 days following enrollment: hospitalization or intravenous rehydration; an unscheduled physician visit, either in a clinic or acute care setting; protracted vomiting or diarrhea; physician order to administer a solution different than the one assigned by randomization

Table 1 Event probabilities and sensitivity analysis ranges used in decision model based on values obtained in the trial[7]

Probabilities	Reference case estimate ^a	Lower 95%	Upper 95%	Distribution
Treatment failure with electrolytes	0.2500	0.2038	0.3009	Beta
Treatment failure with apple juice	0.1672	0.1282	0.2124	Beta
Probabilities in apple Juice treatment strategy				
Hospital admission at index visit	0.0185	0.0005	0.0989	Beta
Hospital admission at follow-up	0.0556	0.0116	0.1539	Beta
Hospital transfer	0	0	0.0660	Beta
Intravenous rehydration at index visit	0.0556	0.0116	0.1539	Beta
Intravenous rehydration at follow-up	0.1111	0.0419	0.2263	Beta
Unscheduled physician visit	0.4630	0.3262	0.6039	Beta
Unscheduled ED visit	0.3519	0.2268	0.4938	Beta
Crossover to electrolytes	0.0370	0.0045	0.1275	Beta
Ondansetron use with apple juice failure	0.6667	0.5253	0.7891	Beta
Ondansetron use with apple juice success	0.6617	0.6018	0.7180	Beta
Probabilities in electrolyte treatment strategy				
Hospital admission at index visit	0.0741	0.0277	0.1543	Beta
Hospital admission at follow-up	0.0617	0.0203	0.1382	Beta
Hospital transfer	0.0494	0.0136	0.1216	Beta
Intravenous rehydration at index visit	0.2716	0.1787	0.3819	Beta
Intravenous rehydration at follow-up	0.1358	0.0698	0.2300	Beta
Unscheduled physician visit	0.3333	0.2324	0.4468	Beta
Unscheduled ED visit	0.3704	0.2656	0.4849	Beta
Crossover to apple juice	0.1111	0.0521	0.2005	Beta
Ondansetron use with electrolyte failure	0.8272	0.727	0.9022	Beta
Ondansetron use with electrolyte success	0.6379	0.574	0.6983	Beta

^aAll values obtained from trial data [7]

Table 2 Costs, quantities, and sensitivity analysis ranges used in decision model

Parameter	Reference case estimate	Source	Lower 95%	Upper 95%	Distribution*
Direct costs*					
Apple juice	\$ 4.38	Local pricing	\$ 1.00	\$ 5.00	Uniform
Electrolyte maintenance solution	\$ 22.00	Local pricing	\$ 15.74	\$ 26.00	Uniform
Index ED visit [†]	\$ 227.55	OCCI [15]	\$ 1.03	\$ 4090.78	Gamma
ED physician	\$ 84.70	Physician fee schedule [16]	\$ 55.90	\$ 98.35	Uniform
Ambulance	\$ 240.00	Ontario Ministry of Health [‡]			Fixed
Admission for indication (treatment failure) [†]	\$ 4461.83	OCCI [15]	\$ 73.80	\$298,737.28	Gamma
Physician consult for admission day 1	\$ 228.02	Physician fee schedule [16]	–	–	Fixed
Physician consult during admission subsequent days	\$ 79.50	Physician fee schedule [16]	–	–	Fixed
Intravenous rehydration in ED	\$106.44	Freedman, 2010 [26]	\$ 79.83	\$ 141.12	Gamma
Unscheduled physician visit after discharge	\$ 36.85	Physician fee schedule [16]	–	–	Fixed
Quantity of unscheduled physician visits					
Apple juice failure	1.08	RCT [7]			
Electrolyte failure	1				
Unscheduled ED visit after discharge [†]	\$ 227.55	OCCI [15]	\$ 1.03	\$ 4090.78	Gamma
Quantity of unscheduled ED visits					
Apple juice failure	1	RCT [7]			
Electrolyte failure	1				
Ondansetron (oral)	\$ 3.27	Ontario Drug Benefit Formulary [28]	\$ 1.64	\$ 4.93	Uniform
Productivity costs					
Lost productivity for 1 day missed from work/usual activities for one parent (female)	\$ 212.65	Statistics Canada [17]	\$0	\$ 471.69	Normal

All costs reported in 2019 Canadian dollars

OCCI Ontario Case Costing Initiative [15], RCT randomized-controlled trial previously published based on this cohort [7]

*For cost parameters assigned a uniform distribution, a minimum and maximum value was used for sensitivity analysis

[†]Hospital overhead costs are included in the estimates from OCCI (for both ambulatory and inpatient stays)

[‡]Ontario Ministry of Health, Ambulance Billing Services: <http://www.health.gov.on.ca/en/public/publications/ohip/amb.aspx>

(i.e., crossover); documented 3% or greater weight loss or a Clinical Dehydration Scale score [13] of five points or higher at any in-person follow-up within 7 days.

Cost measurement and valuation

Intervention costs, direct healthcare costs, and indirect costs associated with caregiver productivity losses were included in the societal perspective, while productivity losses were excluded for the health care payer perspective (Table 2). A macrocosting approach was utilized to calculate total pathway costs. Intervention costs consisted of the cost of electrolytes or apple juice, and were based on local, commercially available pricing. Health care resource use reported in the trial was obtained by chart review supplemented by direct caregiver interviews. Resource use included repeat ED visits, hospitalizations at the index visit or during follow-up, unscheduled physician visits, intravenous rehydration,

ondansetron use, and transfers for hospitalization at other hospitals. The use of ondansetron was at the discretion of treating physicians in the ED. Children who receive electrolytes do not drink and may be more likely to feel nauseated and be treated with ondansetron. Ondansetron was administered as per local treatment protocols to minimize vomiting, but did not contribute to the treatment failure composite score (Table 1). All transfers from the tertiary hospital for admission at community hospitals [14] were assumed to occur by ambulance. Unit pricing for ambulatory and inpatient stays were obtained from the Ontario Case Costing Initiative [15]. The Ontario Case Costing Initiative is a database of hospital-submitted, patient-level costs, for inpatient and ambulatory care cases in Ontario. Summary costs and length of stay (means, ranges) can be retrieved based on a most responsible diagnosis, defined by ICD-10. Clinicians (SS, SF) determined the likely most responsible diagnosis for this cohort of patients and Ontario case costs were then

retrieved. The length of stay observed in the study cohort was aligned with the values obtained from OCCI. Physician fees were obtained from the Ontario Schedule of Benefits for Physician Services [16]. Caregiver time lost for paid or unpaid labor, applied only for the societal perspective, was calculated based on the number of days the child received care. It was assumed that caregivers lost 1 day of work/usual activity for each day the child was hospitalized or in the ED, and for each medical visit during the follow-up interval. No additional lost productivity was assigned once children went home, unless the child returned to the ED or was readmitted, and productivity hours were allocated in the same manner. Lost productivity was monetized using the Human Capital approach by applying the average daily wage for adults in Ontario [17]. All costs were reported in 2019 Canadian dollars (average 2019 exchange rate \$1 CAD = \$0.75 USD).

Cost-effectiveness analysis

A decision tree was constructed to describe the treatment pathway for patients in the trial who were randomized to either of the two treatment groups. The decision tree begins at presentation in the ED and terminates upon the completion of the follow-up assessment, i.e., 14 days after enrollment. Within each group, the probability of treatment failure was populated from the trial data. A mean cost per patient was calculated for each pathway from resource use captured in the study and assigned to the terminal nodes. Likewise, treatment failure was assessed based on study data and assigned at the terminal nodes. Each parameter in the model was assigned a point estimate, range, and probability distribution (Tables 1 and 2). For one-way sensitivity analyses, each variable was

varied across a specified interval based on clinical data (Table 1), whereby a 95% CI was calculated for each probability observed in the trial. For cost parameters, the range of values from the publicly available sources was used in the sensitivity analysis (Table 2). The 95% CI was also used to establish a range for the PA which varied all parameters simultaneously. A probabilistic analysis is preferred to a deterministic analysis as it directly incorporates uncertainty in multiple parameters simultaneously. Each parameter in the model was assigned a point estimate, a plausible range reflecting that uncertainty, and a probability distribution (Tables 1 and 2). The probabilistic analysis was conducted by running 10,000 Monte Carlo simulations drawing randomly from values in each distribution to determine expected values for mean cost and mean treatment failures per patient, respectively, for each group. Incremental cost-effectiveness was examined by calculating the difference in mean costs per patient and in mean number of treatment failures between groups. The probabilistic analysis generated a probabilistic point estimate and 95% confidence intervals (CI) for incremental costs and incremental effectiveness. Results are presented in a scatter plot of incremental costs vs incremental effectiveness showing the pairwise values for each iteration of the probabilistic analysis. The ability to derive 95% CIs in a probabilistic analysis is a useful feature to provide decision-makers with an indicator of precision alongside the incremental values. One-way sensitivity analyses of probabilities and costs were performed to assess the impact of uncertainty in the parameter estimates on the results. Sensitivity analysis examined the impact of productivity loss for one and two parents. Ranges for sensitivity analyses were obtained by calculating 95% CIs from trial data

Table 3 Probabilistic analysis comparing apple juice/preferred fluids to electrolytes for the treatment of gastroenteritis, societal and health care system perspectives

Strategy	Perspective*	Mean cost per patient (95% CI)	Mean treatment failure per patient (95% CI)	Cost-effectiveness
Apple juice/preferred fluids	Societal	\$638 (\$196, \$1424)	0.17 (0.13, 0.21)	DOMINANT (less costly, more effective)
	Health care system	\$402 (\$114, \$1146)		
Electrolyte maintenance solution	Societal	\$808 (\$247, \$2253)	0.25 (0.20, 0.30)	
	Health care system	\$550 (\$155, \$1974)		
Incremental	Societal	− \$171 (− \$1097, − \$22)	− 0.08 (− 0.15, − 0.02)	
	Health care system	− \$147 (− \$1056, − \$23)		

Overall costs and effects are represented from both societal and health care payer perspectives for each of the two treatment strategies. The incremental values and 95% CIs represent the additional cost (or effect) per child and are determined by PA. As the electrolyte strategy is dominated, an incremental cost-effectiveness ratio is not warranted [9, 10]

CI confidence interval. All costs in 2019 \$ CAD

*Societal perspective includes all direct and indirect health care costs as well as parent productivity losses. Health care payer perspective does not include any costs related to parent lost productivity

Fig. 1 Incremental cost vs incremental effectiveness scatterplot

or using ranges observed in publicly available sources (Tables 1 and 2). The trial included 323 participants randomized to receive apple juice/preferred fluids (mean age 28.0 ± 15.4 months, 53.6% males) and 324 assigned electrolytes (mean age 29.0 ± 16.5 months, 48.8% males). At baseline, 68.0% of participants had a Clinical Dehydration Scale score of 0 (i.e., no signs of dehydration) with only 6% having baseline scores ≥ 3 points [5].

Results

The results of the probabilistic analysis are presented in Table 3. The mean cost per patient for the apple juice/preferred fluids intervention was \$637 which was less costly than the \$808 in the electrolytes strategy from a societal perspective. This yielded an incremental saving per child of \$170 (95% CI \$22 to \$1097). Similarly, cost savings were observed when only a health care perspective was taken, \$147 (95% CI \$23 to \$1056) (Table 3). The randomized-controlled trial revealed that the apple juice/preferred fluids' group demonstrated a significantly lower probability of overall treatment failure compared to electrolytes: 16.7% [95% CI 12.8 to 21.2] versus 25.0% [95% CI 20.4 to 30.1] [7]. There was an average of 0.08 fewer treatment failures per child in the juice group versus the electrolytes group (95% CI -0.15 to -0.02). The superior effectiveness of the apple juice/preferred fluids' intervention was such that it demonstrated fewer treatment failures in 99% of the model iterations (Fig. 1). As it was more effective and less costly, the apple juice/preferred fluids' intervention was dominant, precluding the need to calculate an incremental cost-effectiveness ratio.

The results of the one-way sensitivity analysis showed that the apple juice/preferred fluids' intervention remained a cost-saving strategy across all ranges in the parameters (Tables 1 and 2), including the probability of treatment failure or subsequent hospital admission in the apple juice group. When electrolytes failure rates were varied within the specified ranges, the savings per patient ranged from \$121 to \$225. When apple juice failure rates were varied, the cost savings per patient ranged from \$139 to \$197. The largest ranges for costs savings were seen when varying the costs of admission (\$75 to \$6515), the number of days of hospitalization (\$155 to \$1081), and the cost of an emergency department visit (\$161 to \$325).

Discussion

Children with none-to-minimal dehydration secondary to acute gastroenteritis who seek ED care require safe and effective rehydration. The results indicated that in the study population, the use of apple juice/preferred fluids is both less costly and more effective than electrolytes. The cost-effectiveness estimate remained stable in sensitivity analyses, supporting the robustness of the findings. The majority of treatment failures were due to the decision by caregivers to seek ongoing care, which contributed to the higher costs in the electrolytes group. In addition, costs in the electrolytes group were greater from the societal perspective because of greater lost parent productivity associated with health care visits.

Although this economic analysis was based on the results of a single randomized-controlled trial, the uncertainty associated with a few data sources was addressed by performing a probabilistic analysis. Moreover, the

probabilistic analysis indicated that greater than 99% of the iterations demonstrated that apple juice/preferred fluids option was less costly and resulted in fewer treatment failures. A wide range in the potential savings was observed reflecting the large variation in per patient ED costs for gastroenteritis noted in this population. This likely reflects a wide range of severity of cases that would exist in the OCCI dataset. This finding indicates that savings will vary between institutions depending on severity of disease and likelihood of a hospital admission. As guidelines increasingly recommend dilute apple juice use in children without dehydration at home [1], this analysis provides decision-makers with a high degree of confidence in the cost-effectiveness of implementing this practice change in the hospital setting.

These findings are important given that most children with gastroenteritis have relatively mild disease and are cared for at home without seeking medical care [18]. Indeed, a few children in high-income countries develop severe dehydration, and the majority receive oral rehydration therapy [19]. The findings of this study highlight the savings that a healthcare system may realize with the adoption of the apple juice/preferred fluids' approach to care. While the effectiveness of apple juice/preferred fluids in the non-ED outpatient setting was not studied, it is reasonable to postulate that the adoption of this strategy in community settings would further reduce the cost of gastroenteritis care. Since many children with mild gastroenteritis are managed at home, there may also be societal savings due to reduced time losses for caregivers and reduced out-of-pocket costs to purchase electrolytes supplies.

Historically, the use of electrolytes was considered the standard of care for children with mild gastroenteritis to minimize risk and prevent severe dehydration [2]. This practice was in part based on the perceived potential of beverages with high glucose content to induce osmotic diarrhea [2, 20]. However, this assumption has been refuted in the randomized-controlled trial upon which the present analysis was based as well as in the previous studies [21, 22]. The present findings of improved clinical outcomes and reduced costs in the apple juice/preferred fluid strategy represent the consequence of augmented fluid intake that occurs when children are offered a more palatable liquid [4]. The higher fluid consumption and improved general well-being likely translated in a decrease in treatment failure and lower consumption of healthcare resources.

The randomized-controlled trial on which the present analysis was based included children with disease severity typical of that seen in EDs in most high-income countries. While the possibility of adverse events associated with the apple juice/preferred fluids strategy cannot be excluded, the study population of children over 6 months of age without comorbidities or moderate-to-severe dehydration

did not exhibit any concerning findings. Moreover, rotavirus vaccination is now universally provided in most high-income countries, thereby dramatically reducing the most common etiology of severe dehydrating diarrhea and electrolyte disturbances [23]. Intravenous rehydration is painful [24] and associated with iatrogenic risks [25]. Use of apple juice/preferred fluids option can prevent unnecessary exposure to this procedure. The present economic evaluation informs the optimal gastroenteritis management strategy by quantifying the cost savings of a relatively simple patient-centered change in practice. This practice change may result in savings to institutions proportional to their pediatric gastroenteritis case volumes, and to health care systems and payers, without negatively impacting clinical outcomes. In countries where health care resources and funds are particularly constrained, such as in low- and middle-income nations, savings from low-cost substitutes could be significant to health institutions and healthcare budgets. Research would be required to estimate the potential for savings using local price weights and effectiveness data.

There are some limitations worth noting. The economic evaluation was based on a single randomized-controlled trial rather than a meta-analysis of pooled effectiveness as no other similar trials have been conducted. Thus, this analysis was subject to the same limitations as the original RCT. That trial was performed in a large urban tertiary care center in a high-income country with universal healthcare funded by a single payer. Therefore, the findings are generalizable primarily to settings and regions with comparable clinical risks and access to health care services with similar costs. Similar to the original trial, the findings may be less applicable to low resource settings and low- and middle-income nations. However, we previously demonstrated that the health system savings in the United States, relative to Canada, for a similarly dominant intervention administered to children with acute gastroenteritis in ED would be 38 times greater [26]. In addition, the subjects in this trial were enrolled over a 5-year interval between 2010 and 2015. It is possible that changes in ED visits for gastroenteritis may have occurred since that time. Although this analysis was based on data from a single randomized-controlled trial, it had high internal validity and extensive sensitivity analyses were performed reinforcing the robustness of the findings. The use of datasets from other institutions, both locally and internationally, to validate the findings may assist in expanding the generalizability of this work.

The use of medical services during follow-up and unscheduled health care visits counts were based on caregiver reports and parent-completed diaries (i.e., caregivers recorded healthcare visits, missed time from work, and out-of-pocket expenses on a daily basis) which may be subject

to recall bias. However, participating families were followed for a short time-frame, 14 days post-enrollment, and it is unlikely that parents would have forgotten a visit to their doctor or a repeat ED visit. Parents have been demonstrated to be reliable reporters of their children's urgent care visits for intervals up to 1 year [17].

Finally, only children with none-to-minimal dehydration presenting to the ED were studied and these findings cannot be generalized to those with more severe disease. While it is not known if the fluid replacement choices in the non-ED outpatient setting would be the same, it is clinically reasonable to generalize the benefits of the apple juice/preferred fluids strategy to the care of children not requiring ED care as the severity of their disease would likely be milder, and related cost savings greater. Based on this assumption, the use of dilute apple juice is recommended for such children [1]. Incorporation of these findings into practice guidelines may help with future enhancement of effective knowledge translation of these findings and with overcoming potential barriers associated with this practice change. Moreover, this study supports more efficient use of limited resources, thereby facilitating improved decision-making at the point of care [27].

Conclusions

This study demonstrated that using apple juice/preferred fluids was cost-effective compared to electrolytes in the management of children with none-to-minimal dehydration secondary to acute gastroenteritis, resulting in both lower costs and fewer treatment failures. Given the high prevalence of gastroenteritis in this population and the relatively simple management change proposed, these findings may have a significant economic impact.

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Declarations

Conflict of interest The authors have no conflicts of interest to declare.

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