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# Survey of current maintenance intravenous fluids prescribing practices among Egyptian pediatricians

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## Abstract

**Background** Recent research has firmly linked the administration of hypotonic fluids with the incidence of hospital-acquired hyponatremia in pediatric patients.

**Objective** This study examined the prevailing practices in prescribing maintenance intravenous fluids (mIVFs) among Egyptian pediatricians, assessed the compliance of current prescribing practices with the American Academy of Pediatrics Clinical Practice Guidelines (AAP-CPG), and emphasized the urgency for revised educational initiatives.

**Materials and methods** To recruit pediatricians for this study, a convenience and snowballing sampling methods were used. The questionnaire was created in Google Forms and then distributed in English to Egyptian Facebook groups devoted to pediatric education. The data collection phase started on January 1, and ended on February 28, 2022. Different case scenarios with increased antidiuretic hormone were introduced, and respondents were asked to choose the optimum mIVFs in each case scenario. Finally, respondents were directly asked how often they use isotonic fluids as their primary mIVFs and what caused them to not use isotonic fluids.

**Results** For this study, a total of 513 participants were included. The survey revealed that Egyptian pediatricians did not fully comply with AAP-CPG regarding the mIVFs in pediatrics. Hypotonic fluids are still preferred, but there is a shift towards 0.45% sodium chloride (NaCl) from the previously favored 0.2% NaCl. Isotonic fluids are more common in older age groups and conditions that involve potential excessive antidiuretic hormone secretion, while 0.2% NaCl remains popular in neonatal care. Balanced solutions are underused, indicating practice variation.

**Conclusions** The utilization of isotonic fluids in the treatment of neurologic conditions has experienced a notable increase, propelled by heightened awareness and a growing demand for continuous medical education. To comprehensively address concerns related to fluid management beyond the scope of AAP-CPG, it is imperative to conduct multicenter studies across governmental, private, and educational pediatric healthcare settings to assess and improve pediatricians' clinical practice.

**Keywords** Pediatrics, Maintenance intravenous fluids, Hypotonic fluids, Pediatrics clinical practice guideline

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## Background

Acutely ill children often present with an overproduction of arginine vasopressin (AVP), which results in compromised free-water excretion. Consequently, these patients face an elevated susceptibility to hyponatremia, along with potentially severe neurological complications, particularly when hypotonic fluids are administered [1]. Maintenance of intravenous fluids (mIVFs) represents a crucial form of supportive care for critically ill children [2]. Notably, isotonic mIVFs are endorsed by both the 2015 National Institute for Health and Care Excellence recommendations and the 2018 American Academy of Pediatrics Clinical Practice Guidelines (AAP-CPG) as the preferred choice for most children [2, 3]. Despite the widespread use of mIVFs, fluid prescription practices exhibit considerable divergence among pediatricians [4–7]. Although traditional treatment involved hypotonic fluids for children, a significant debate arose after the documented instances of severe hyponatremia and hyponatremic encephalopathy in 1992, prompting a thorough examination of optimal mIVF strategies [6–9]. Over the past 15 years, numerous clinical trials and systematic reviews have sought to address this critical issue [3, 10–14].

Numerous surveys have assessed the prescribing practices of mIVFs in pediatrics, with most focusing on anesthesiologists and revealing widespread utilization of hypotonic fluids [6, 7, 15, 16]. However, limited research has explored the current landscape of mIVFs practices in acutely ill children, especially in light of the release of the AAP-CPG guidelines in 2018 [17]. The primary objective of this study was to assess the current prescription practices of mIVFs among pediatricians in Egypt. This assessment entails an examination of the extent to which Egyptian pediatricians adhere to the 2018 AAP-CPG guidelines, which are recognized as the approved standard in Egypt for such practices. Furthermore, the study intended to look deeper into the various factors that influence these prescription practices.

## Methods

A convenience and snowballing sampling methods were used to recruit pediatricians for this study. The questionnaire was created using Google Forms and then distributed in English to Egyptian Facebook groups dedicated to pediatric education. We modified a previously published survey, using it as a foundational framework, to ensure its alignment with the context of Egyptian pediatricians [6]. The data collection phase began on January 1, and ended on February 28, 2022.

## Sample size

Given the lack of a published study on mIVFs prescribing practices in Egypt, we assumed that 50% of pediatricians use isotonic solutions. Using EPI-Info 7.2, the minimum required sample size was determined to be 480 responses with a type 1 error of 5%, a power of 80% ( $1-\beta$ ), and a response rate of 80%. We increased the number of responses to 550 to account for inconsistent or incomplete responses [18].

## Data collection

The respondents were asked about demographic data: current job position, hospital category, country where they practice pediatrics, and completion time of pediatric residency. Then, they were asked about their primary mIVFs in different age categories (neonates, infants aged 28 days until 1 year, and from 1 to 18 years). Assuming the addition of appropriate dextrose and potassium chloride to intravenous fluids, with patients being euvolemic, the options considered include isotonic fluids such as normal saline and Ringer lactate, as well as hypotonic fluids like 0.2% sodium chlorid (NaCl) and 0.45% NaCl. Different case scenarios with increased antidiuretic hormone (ADH) were introduced, and respondents were asked to choose the optimum mIVFs in each case scenario. Finally, respondents were directly asked how often they use isotonic fluids as their primary mIVFs and what caused them to not use isotonic fluids.

## Statistical analysis

Categorical data were expressed as numbers and percentages. Chi-square and Fisher exact tests were used to compare the factors that affect the application of the AAP-CPG guidelines. Significance level was set at  $P < 0.05$ . We used the Statistical Package for the Social Sciences (SPSS, IBM, version 25) to conduct the statistical analysis.

## Results

### Respondents characteristics

Of the total of 550 responses received, 37 incomplete or inconsistent responses were excluded from the analysis. The demographic characteristics of the remaining 513 respondents are presented in Table 1. Almost four-fifths (79.9%) of the pediatricians included participated in pediatric practice in Egypt. Notably, specialists constituted the largest segment, accounting for 284 individuals, equivalent to 55.4% of the participants. Most respondents, comprising 76.0% ( $n = 390$ ), were prominently affiliated with governmental healthcare establishments. In terms of completion of residency training, 293 respondents (57.1%) had finished their training between 2010 and

**Table 1** Characteristics of the survey population

Variable (n = 513)		Number	%
Position	Resident	198	38.6
	Specialist	284	55.4
	Consultant	31	6.0
Country of practice	Inside Egypt	410	79.9
	Outside Egypt <sup>a</sup>	103	20.1
Hospital category	Governmental healthcare facility	390	76.0
	University/teaching hospital	123	24.0
The years during which residency was completed	Before 2000	24	4.7
	2000–2009	40	7.8
	2010–2019	293	57.1
	Not completed	156	30.4

<sup>a</sup> Countries outside Egypt: Kingdom of Saudi Arabia, Libya, United Arab Emirates, Oman, Non-Arab countries

2019, while 156 respondents (30.4%) had not completed their residency training yet. Tables 2, 3, and 4 present the primary choice of mIVFs selected by participants within different age categories. Notably, 0.45% NaCl emerged as the predominant choice among respondents in the age categories of (28 days to 1 year) and (1–18 years), with utilization rates of 54.6% and 62%, respectively. In the same vein, among infants aged (28 days to 1 year), 0.2% NaCl was preferred by 32.6%, while among children aged (1–18 years), 0.9% NaCl was preferred by 19.3%. Conversely, in the age category <28 days, 0.2% NaCl was the most frequently administered choice, with an adoption rate of 73.9%. Despite the relatively low overall prescription rate for isotonic fluids (15.4%), a nuanced

perspective emerged when analyzing age categories. Specifically, the usage of isotonic fluids was notably higher among respondents in the older age group (1 to 18 years) as compared to the other age groups (28 days to 1 year, and <28 days), corresponding to rates of 22.6%, 12.9%, and 10.7%, respectively ( $P=0.031$ ). For respondents who dealt with infants aged <28 days, it was observed that almost two-thirds chose 0.2% NaCl in various factor strata. Regarding isotonic fluids, none opted for ringer lactate, the percentage of normal saline usage was 12% for residents, governmental health facilities, and those who had completed their residency between 2010 and 2019. Furthermore, a usage rate of 11.5% was observed among pediatricians practicing in Egypt. Table 2 On the contrary, among the older age groups (infants 28 days to 1 year) and (children 1–18 years), a substantial proportion of 54.6% and 62.0%, respectively, favored 0.45% NaCl. Notably, the prescription pattern for isotonic fluids was influenced by factors such as being a consultant or specialist. The trend extended to the use of balanced crystalloids, which were increasingly adopted beyond the neonatal age, accounting for 1.0% among infants and 3.3% among older children. Consultants and individuals who work in universities and teaching hospitals were particularly prominent in prescribing balanced crystalloids. Furthermore, in the age category of children aged 1 to 18 years, those who had completed their residency before 2000 exhibited the highest preference for ringer lactate (10.0% and 8.3% respectively) (Tables 3 and 4).

#### Case scenarios

When presented with different scenarios involving an increased likelihood of excessive ADH secretion, the

**Table 2** Description of some factors that affect using different concentrations of mIVFs according to age categories (Maintenance IVFs for neonates < 28 days)<sup>a</sup>

Variable		0.2% NaCl	0.45% NaCl	0.9% NaCl
		Number (%)	Number (%)	Number (%)
Position	<b>Total (N = 513)</b>	379 (73.9%)	79 (15.4%)	55 (10.7%)
	Resident	154 (77.78%)	21 (10.6%)	23 (11.62%)
	Specialist	204 (71.8%)	51 (18.0%)	29 (10.2%)
	Consultant	21 (67.7%)	7 (22.6%)	3 (9.7%)
Country of practice	Egypt	310 (75.6%)	53 (12.9%)	47 (11.5%)
	Outside Egypt	69 (67.0%)	26 (25.2%)	8 (7.8%)
Hospital category	Governmental healthcare facility	292 (74.9%)	50 (12.8%)	48 (12.3%)
	University/teaching	87 (70.7%)	29 (23.6%)	7 (5.7%)
The years during which residency was completed	Before 2000	17 (70.8%)	4 (16.7%)	3 (12.5%)
	2000–2009	26 (65.0%)	11 (27.5%)	3 (7.5%)
	2010–2019	212 (72.4%)	47 (16.0%)	34 (11.6%)
	Not completed yet	124 (79.5%)	17 (10.9%)	15 (9.6%)

<sup>a</sup> For this age category, no respondent chose ringer lactate

**Table 3** Description of some factors that affect using different concentrations of mIVFs according to age categories (Maintenance IVFs for infants 28 days–1 year)

Variable		0.2% NaCl Number (%)	0.45%NaCl Number (%)	0.9% NaCl Number (%)	Ringer lactate Number (%)
	<b>Total (N= 513)</b>	<b>167 (32.6%)</b>	<b>280 (54.6%)</b>	<b>61 (11.9%)</b>	<b>5 (1.0%)</b>
<b>Position</b>	Resident	62 (31.31%)	112 (56.57%)	23 (11.62%)	1 (0.5%)
	Specialist	94 (33.1%)	153 (53.9%)	34 (12.0%)	3 (1.1%)
	Consultant	11 (35.5%)	15 (48.4%)	4 (12.9%)	1 (3.2%)
<b>Country of practice</b>	Egypt	140 (34.1%)	217 (52.9%)	50 (12.2%)	3 (0.7%)
	Outside Egypt	27 (26.2%)	63 (61.2%)	11 (10.7%)	2 (1.9%)
<b>Hospital category</b>	Governmental healthcare facility	137 (35.1%)	203 (52.1%)	48 (12.3%)	2 (0.5%)
	University/teaching	30 (24.4%)	77 (62.6%)	13 (10.6%)	3 (2.4%)
<b>The years during which residency was completed</b>	Before 2000	8 (33.3%)	11 (45.8%)	5 (20.8%)	0 (0.0%)
	2000–2009	15 (37.5%)	22 (55.0%)	2 (5.0%)	1 (2.5%)
	2010–2019	93 (31.7%)	156 (53.2%)	41 (14.0%)	3 (1.0%)
	Not completed yet	51 (32.7%)	91 (58.3%)	13 (8.3%)	1 (0.6%)

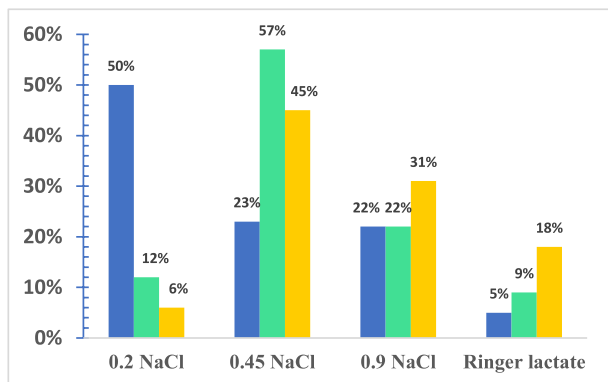
**Table 4** Description of some factors that affect using different concentrations of mIVFs according to age categories (Maintenance IVFs for children 1–18 years)

Variable		0.2% NaCl Number (%)	0.45%NaCl Number (%)	0.9% NaCl Number (%)	Ringer lactate Number (%)
	<b>Total (N= 513)</b>	<b>79 (15.4%)</b>	<b>318 (62.0%)</b>	<b>99 (19.3%)</b>	<b>17 (3.3%)</b>
<b>Position</b>	Resident	21 (10.6%)	125 (63.2%)	43 (21.7%)	9 (4.5%)
	Specialist	53 (18.7%)	174 (61.3%)	51 (18.0%)	6 (2.1%)
	Consultant	5 (16.1%)	19 (61.3%)	5 (16.1%)	2 (6.5%)
<b>Country of practice</b>	Egypt	68 (16.6%)	252 (61.5%)	77 (18.8%)	13 (3.2%)
	Outside Egypt	11 (10.7%)	66 (64.1%)	22 (21.4%)	4 (3.9%)
<b>Hospital category</b>	Governmental healthcare facility	66 (16.9%)	236 (60.5%)	75 (19.2%)	13 (3.3%)
	University/teaching	13 (10.6%)	82 (66.7%)	24 (19.5%)	4 (3.3%)
<b>The years during which residency was completed</b>	Before 2000	3 (12.5%)	14 (58.3%)	5 (20.8%)	2 (8.3%)
	2000–2009	8 (20.0%)	25 (62.5%)	7 (17.5%)	0 (0.0%)
	2010–2019	52 (17.7%)	176 (60.1%)	56 (19.1%)	9 (3.1%)
	Not completed yet	16 (10.3%)	103 (66.0%)	31 (19.9%)	6 (3.8%)

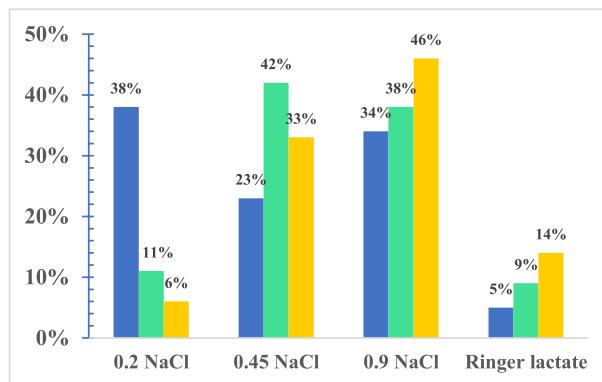
utilization of isotonic fluids in actual clinical practice was observed to be 38%. This is in contrast to a general inquiry, where the usage was found to be 15.4%, indicating a statistically significant difference ( $P=0.016$ ). Figure 1 depicts the practical responses of the participants in various case scenarios categorized by age groups. Specifically, at 20 days of age, the administration of isotonic fluids showed variations according to the specific case scenarios. The prescribing percentages ranged from 22.8% for acute bronchiolitis to 38.8% for traumatic brain injury (TBI). In particular, the preferred mIVFs choice was 0.2% NaCl. Transitioning to the age of 6 months, the prescribing percentages ranged from 26.7% for acute bronchiolitis

to 47.0% for TBI cases. For children aged 12 years old, the figures were 44.1% for post-operative cases and 59.0% for TBI cases. Interestingly, more than 56% of respondents opted for 0.45% NaCl for gastroenteritis and acute bronchiolitis cases at 6 months of age. Although normal saline showed markedly higher usage rates in cases of meningitis and TBI compared to other scenarios in 12-year-old children (37.3% and 44.6%, respectively;  $P=0.001$ ), the predominant fluid choice remained the hypotonic 0.45% NaCl for this particular age group. An intriguing observation was the increased adoption of normal saline for TBI cases across all age groups, including neonates (33.5%, 37%, and 44.6% respectively), at ages 20 days, 6 months, and 12 years ( $P<0.0001$ ).

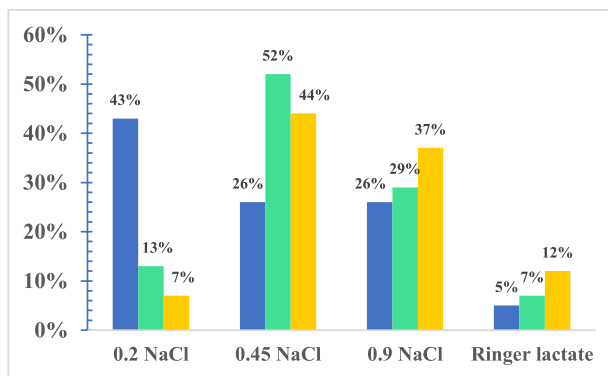
**a. Viral gastroenteritis**



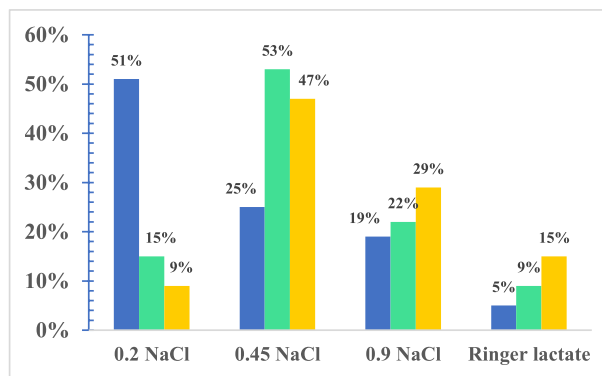
**b. TBI\***



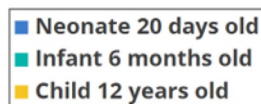
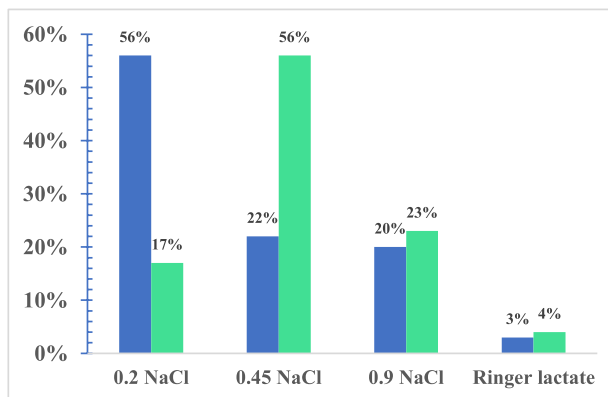
**c. Meningitis**



**d. Post-operative**



**e. Acute bronchiolitis**

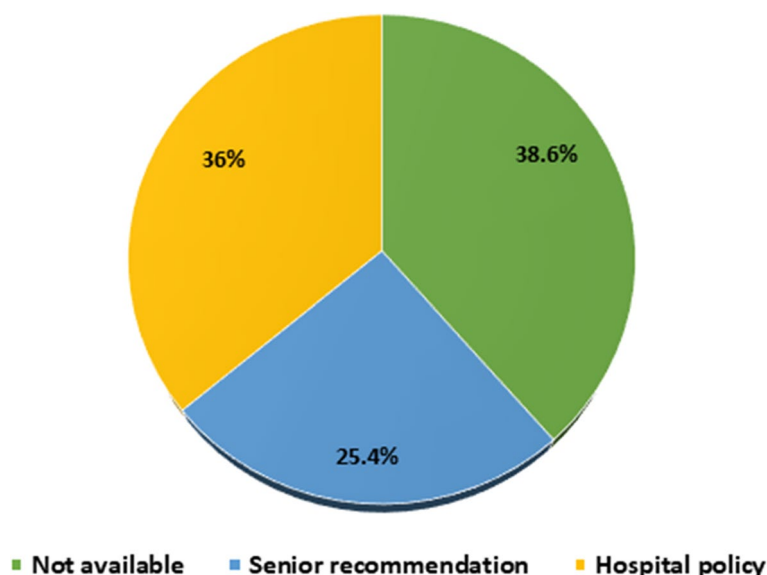


**Fig. 1** Different case scenarios to demonstrate respondents' real practice in prescribing maintenance IVFs at different age categories. \*TBI: traumatic brain injury

**Applying the AAP-CPG guidelines**

Approximately 46% of the respondents indicated that they were unable to implement the AAP-CPG guidelines for the prescription of isotonic fluids to acutely ill children. The rationales behind this inability are shown in Fig. 2. Out of the total respondents, 91 individuals

(38.6%) cited the unavailability of isotonic fluids, while 85 respondents (36%) attributed their inability to the hospital's established policy. Furthermore, 60 participants (25.4%) cited recommendations from senior professionals without discernible hospital protocols as a contributing factor.



**Fig. 2** Reasons for not applying AAP guidelines for prescribing isotonic mIVFs

## Discussion

### Type of mIVFs used

A significant proportion of Egyptian pediatricians continue to use hypotonic fluids as their foremost choice of mIVFs for critically ill children. The utilization of 0.45% NaCl has become more prevalent than the previously favored 0.2% NaCl. This shift could be attributed to increasing recognition of the hyponatremia risk linked to 0.2% NaCl; nevertheless, it is imperative for them to acknowledge that the risk of hyponatremia still persists with the use of 0.45% NaCl.

In the context of neonates, however, 0.2% NaCl remains the predominant mIVFs choice. This trend could potentially be attributed to the limited data available for this specific age group. Furthermore, it is noteworthy that the recommendations from AAP-CPG have excluded the neonatal age group from their guidelines. However, an interesting observation has emerged indicating a growing adoption of less hypotonic fluids, such as 0.45% NaCl, and even isotonic solutions such as 0.9% NaCl, particularly in scenarios involving meningitis or traumatic brain injuries. This emerging preference can be explained by increased awareness of the syndrome of inappropriate antidiuretic hormone secretion (SIADH) associated with neurological disorders or insults.

Our findings are congruent with several previously published surveys that have investigated the prescribing practices of mIVFs in pediatric settings. For example, Freeman et al. [6] demonstrated that pediatric residents in the United States of America (USA) prefer hypotonic fluids as the primary choice of mIVE, even in scenarios involving excessive ADH secretion. Similarly, Davies et al.

[19] reported comparable results, revealing a preference for the use of hypotonic fluids, particularly among pediatric surgeons and anesthesiologists. Considering these insights, it becomes evident that the inclination towards hypotonic fluids persists within pediatric medical practice, underscoring the imperative for heightened awareness and enhanced education concerning the potential risks and considerations associated with varying fluid selections.

During the perioperative phase, Way et al. [15] shed light on the proclivity of anesthesiologists in the United Kingdom to favor hypotonic fluids. Similarly, in Australia, Keijzers et al. [16] demonstrated that hypotonic fluids remained the predominant choice, even in instances involving excessive ADH secretion.

Since the release of the AAP-CGP guidelines, limited surveys have explored the prescription practices of mIVFs, particularly within the realm of pediatrics. Hall et al. [17] conducted a survey illustrating that most surveyed pediatricians opt for isotonic fluids within the age group spanning from 28 days to 18 years. Remarkably, these practitioners were found to be adhering to the AAP-CGP recommendations. Furthermore, the use of hypotonic fluids continues among neonates, with 0.45% NaCl emerging as a more frequently employed option than the previously prevalent 0.2% NaCl.

An alarming observation arises from this study, indicating a notable upsurge in the utilization of isotonic fluids in scenarios where there is a heightened susceptibility to excess ADH secretion. This trend is particularly evident in cases of meningitis and TBI. One possible explanation for this trend is an increased awareness of the incidence

of SIADH in such cases, especially those involving neurological insults.

Of particular significance is the statistically significant increase in the use of isotonic fluids across all age groups, including newborns, in cases of TBI. This phenomenon can be attributed to the influence of continuous medical education efforts. Through repeated explanations and the clear communication of management strategies, a heightened understanding of this topic has been cultivated. This includes a distinct emphasis on the risks associated with the administration of hypotonic fluids in cases of TBI.

Based on the findings, it is strongly recommended that further educational lectures be conducted on this subject across various clinical scenarios. These lectures should comprehensively address the existing evidence and newly formulated guidelines, thereby enhancing healthcare professionals' understanding and guiding appropriate fluid management decisions.

In relation to balanced fluids, we observed a minimal utilization rate of ringer lactate in specific age categories (28 days to 1 year and 1–18 years) at 1% and 3.3% respectively, with no instances of its application in the neonatal age group. This trend might be attributed to the scarcity of available data concerning the use of balanced mIVFs in the pediatric population. Additionally, some existing data advocating for its use in adults could potentially account for these limited rates [20, 21].

Furthermore, when inquiring about the reasons behind non-adherence to the AAP-CPG among those who do not implement them, certain factors came to light. Notably, issues such as the unavailability of pre-made solutions, hospital policies, and recommendations from senior medical staff emerged as prominent causes. These findings underscore the need for heightened awareness and a systematic assessment of the accessibility of appropriate mIVFs. It is imperative that hospital guidelines on fluid management are routinely reviewed and updated. Moreover, the continuous education and upskilling of senior medical practitioners are crucial, given their substantial influence on the practices of junior colleagues. Regrettably, even well-informed junior medical personnel may struggle to implement optimal practices unless their senior counterparts are both persuaded and kept well-informed as well. Worth noting is the absence of analogous outcomes in previous research concerning the rationale behind deviations from the AAP guidelines.

### Strengths and limitations

To our knowledge, this is the first study to survey the practice of Egyptian pediatricians about mIVFs in critically ill and acutely ill children and infants. This is crucial to determine if they follow recent recommendations or if there is malpractice, so that we can

determine the causes of this malpractice and manage them later by improving medical education, checking the availability of different concentrations of mIVFs, and updating hospital policies. However, it is important to acknowledge a limitation inherent to this study. As a self-reported analysis, its findings are contingent upon the perspectives of the respondents, which may not invariably align with actual clinical practice.

### Conclusions

Based on the survey results, it is evident that Egyptian pediatricians are not yet fully adhering to the guidelines established by the AAP about mIVFs in pediatrics. Notably, there remains a prevalent inclination towards the use of hypotonic fluids, although a noticeable shift has occurred towards employing 0.45% NaCl, which represents a departure from the previously favored 0.2% NaCl, a solution of greater hypotonicity. Moreover, a discernible rise is observed in the general utilization of isotonic fluids among older age groups and in scenarios where there is a potential for excessive ADH secretion. Interestingly, during the neonatal phase, 0.2% NaCl maintains its status as the predominant choice. The adoption of balanced solutions for mIVFs remains less frequent, indicating a pattern of practice divergence. Intriguingly, the application of isotonic fluids in instances of neurologic insults, such as meningitis and TBI, exhibits statistically significant augmentation across all age categories. This escalation is attributed to increased awareness, emphasizing the need for continuous medical education. Consequently, there is a clear imperative to expand our knowledge through ongoing professional development initiatives. Furthermore, multicenter clinical trials must be conducted to comprehensively address the disparities between isotonic and hypotonic fluid utilization in real-world medical practice. These investigations should encompass aspects that are not distinctly elucidated by the AAP-CPG, such as the incidence of hypernatremia, hyperchloremia, acidosis, volume overload, and the impact of employing balanced solutions.

### Abbreviations

AAP-CPG	American Academy of Pediatrics Clinical Practice Guidelines
ADH	Antidiuretic hormone
AVP	Arginine vasopressin
mIVFs	Maintenance intravenous fluids
NaCl	Sodium chloride
SIADH	Syndrome of inappropriate antidiuretic hormone secretion
TBI	Traumatic brain injury

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**Authors' contributions**

Conceptualization, investigation, and methodology A.A.A., R.M.G., and S.R.O.; formal analysis R.A.; writing—original draft preparation A.A.A., R.M.G., H.M.B., S.R.O., and Y.A.E.; writing—review and editing A.A.A., R.M.G., H.M.B., S.R.O., and Y.A.E. All authors have read and agreed to the published version of the manuscript. All authors approved the final version of the manuscript and are accountable for all aspects related to the study.

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**Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Declarations****Ethics approval and consent to participate**

This study was approved by the review board of the Faculty of Medicine, Menoufia University.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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