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ORIGINAL RESEARCH

A prospective descriptive study on emergency medicines used most frequently from the emergency medicine packs at Universitas Academic Hospital and the associated financial loss of expired emergency medicines

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Background: Resuscitation trolleys with equipment and medicines for emergencies are required in all clinical areas in hospitals. Emergency medicines kept separately are more likely to expire than non-emergency medicines, as these are generally used less frequently. An updated list of essential emergency medicines was implemented in 2016 at an academic hospital in central South Africa. The aim of this study was to determine the frequency of both the use and the expiry, with associated financial losses, of the emergency medicines on this list.

Methods: A prospective, descriptive study was conducted over a six-month period in 2019. Forms accompanying the emergency packs were returned to the pharmacy whenever packs expired or were opened. These forms were collected and the type and quantity of medicines either used or expired were recorded.

Results: In total, 168 of the returned forms were included. The most frequently used emergency medicines were adrenaline, sodium bicarbonate and Ringer's lactate. Adrenaline use was recorded on 52.8% and 25% of the forms from the adult/paediatric and neonatal emergency packs, respectively. Medicines that were never used included: betamethasone, Darrow's half-strength solution and most of the neonatal pack medications. Neonatal emergency medicine packs were rarely used and the neonatal fluid packs were never used. The total cost of the expired medicines was R7 960.29 (US$569.41 at the time of the study). Adrenaline was the medication that expired most frequently but the greatest financial losses occurred from expired sodium bicarbonate.

Conclusion: The total financial losses were low but can be reduced further. The contents of the emergency packs should be reviewed to possibly reduce the amount of items used infrequently. Also, the removal of those items not recommended in emergency care guidelines could be considered. Ensuring the policy was followed of returning unused medicines close to expiry and redistributing these to high-use areas would further reduce wastage.

Keywords: emergency medicines, expired medicines, financial loss, cost implications, adrenaline, sodium bicarbonate

Introduction

Cardiopulmonary arrest is the abrupt loss of cardiac and respiratory function and requires immediate intervention for successful resuscitation. In-hospital cardiac arrest has a poor outcome, with survival to hospital discharge estimated to be 25.8% in the adult population and 37.9% in the paediatric population in the USA.[1] To ensure that this life-threatening emergency, among others, is promptly treated, a resuscitation trolley containing various equipment and medicines is generally stored within a healthcare facility. Both the American Heart Association (AHA)[2] and the Resuscitation Council of the United Kingdom[3] have stated that a resuscitation trolley is mandatory wherever patients at risk of sudden deterioration are treated. They also recommended healthcare facilities undertake their own risk assessments to determine what resources are mandatory for their resuscitation trolleys, according to local circumstances.[2,3]

In South Africa, it is standard practice to have a resuscitation trolley stocked with essential equipment and medicines available everywhere patient interaction occurs, for example, primary healthcare facilities, hospital wards and hospital outpatient departments. The contents of these resuscitation trolleys are guided by recommendations from various organisations, including the Resuscitation Council of Southern Africa (RCSA), the Emergency Medicine Society of South Africa (EMSSA)[4] and the Ideal Clinic.[5] Each province's Pharmaceutical and Therapeutics Committee (PTC) compiles a list of essential emergency medicines required on resuscitation trolleys appropriate to their own context. This list can further be redefined by a District PTC to suit a district's specific needs.

In keeping with the Ideal Clinic guidelines,[5] the Free State Provincial PTC compiled a list of emergency medicines needed on every resuscitation trolley in hospitals throughout this province. The list of emergency medicines was updated on 25 July 2016. In keeping with the recommendations of the Provincial PTC, Universitas Academic Hospital (UAH) modified this list of emergency medicines according to the hospital's demands to treat a variety of emergencies, including cardiopulmonary arrest. These medicines are packed in sealed containers and stored on the resuscitation trolley for each clinical area in the hospital.

The medicines kept in these sealed containers for specific use in emergencies may be used infrequently, depending on how often a clinical area has an emergency. This may lead to medicines

expiring, which then need to be discarded at financial loss to the hospital. South Africa is a developing country that cannot afford to waste money on expired medicines. Although there are guidelines in place at UAH to ensure that stock is used before expiry dates are reached, it is not uncommon to find emergency medicines returned to the pharmacy because they have expired. This may be attributed to staff shortages to oversee the monitoring of medications nearing expiry dates and returning these to the pharmacy timeously for redistribution to areas of higher demand before expiry.

The authors found no international literature on the financial losses specific to expired emergency medicines in hospitals. No audit has been done either at UAH or in the Free State Province on the efficacy and financial viability of the emergency medicine packs since updated in 2016. This study was therefore performed to determine whether the medicines, and their quantities, provided on the resuscitation trolleys are practical and whether the hospital is suffering unnecessary financial losses due to wastage of expired medicines from these emergency packs.

The primary aim of this study was to determine which medicines from the emergency medicine packs, and the amounts, were used most frequently at UAH. The secondary aim was to determine which medicines in these emergency packs expired most often and the financial losses associated with discarding these.

(In this article, the term "medicine(s)" collectively refers to medications and fluids).

Methods

Study design and setting

A prospective, descriptive study was conducted at UAH, a tertiary level training hospital in the Free State Province of central South Africa. All wards, outpatient departments, high-care units, intensive care units (ICU) and theatre recovery rooms were included in the study sample.

Study sample and data collection

The routine practice at UAH is for the pharmacy to supply each clinical area with an emergency trolley including an emergency medication pack and a separate emergency fluid pack. Two types of emergency medicine pack were provided – adult/paediatric packs (supplied to 73 wards/clinics) and neonatal packs (supplied to the neonatal ICU, neonatal high-care unit, baby room and labour ward – four areas in total). The contents of these packs are stored in sealed plastic containers. Sodium bicarbonate, dextrose 50% and water for injection, although fluids, are stored in medication packs, and are used as medications or diluents rather than volume replacement agents. A form is included in the containers and states the date of packaging, expiry date, content and quantity of the emergency medicines, and name of the pharmacist who packed the container. The expiry date of emergency packs is determined by the medicine in the pack due to expire first. Whenever an emergency occurs, the pack is opened to access the emergency medicines. The container with the remaining medicines is then returned to the pharmacy on conclusion of the emergency treatment.

At the pharmacy, the medicines used during the emergency are replaced, the container is resealed and returned to the relevant clinical area. The emergency packs are checked every day by nursing staff in each clinical area to ensure medicines have not expired. The emergency packs should be returned to the pharmacy three months before the expiry date displayed on the container, to ensure medicines due to expire are distributed to areas where they can be used before expiration. The returned forms must be stored in the pharmacy for five years. According to the pharmacy price list at the time of the study, the total cost of one adult/paediatric emergency pack (medication and fluid) was R891.97 (US$93.80 – Rand/Dollar exchange rates given in this report are those at the end of the study period in 2019) and the cost of one neonatal emergency pack (medication and fluid) was R1 151.91 (US$82.40).

For this study, the forms accompanying the emergency packs were collected weekly from the pharmacy by the principal researcher (ST). A pilot study (1–14 May 2019) confirmed that the data collection forms were adequate and no changes were required. The main study was performed for a six-month period from 1 July to 31 December 2019.

The medicines used, their quantity and the medicines that expired were recorded.

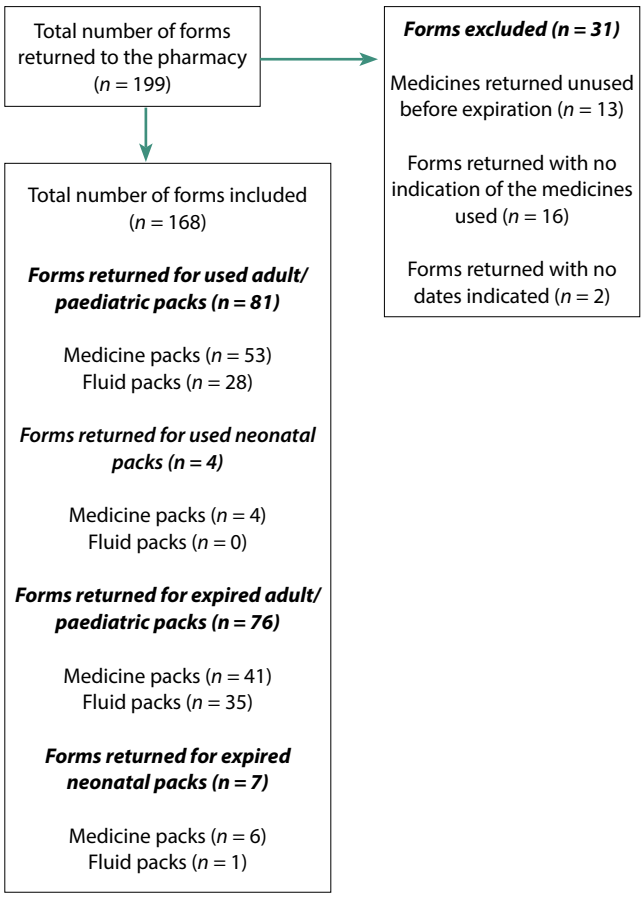

Figure 1: Flow diagram indicating the number of forms either included or excluded from the study

Data analysis

The data collection sheets were analysed to determine which medicines had been used from the adult/paediatric and neonatal emergency packs. In addition, data collection sheets were also analysed regarding the medicines from these packs that were returned to the pharmacy after it had already expired. The costs associated with the expired medicines were calculated from the price list supplied by the pharmacy.

All forms returned to the pharmacy during the study period were considered in the study. However, incomplete forms and those for medicines returned to the pharmacy unused, but before expiry, were excluded from the data analysis (Figure 1).

Results

Of the 199 forms obtained during the study period, 168 (84.4%) were suitable for analysis. The forms were categorised as returned for: used adult/paediatric packs (n = 81); used neonatal packs (n = 4); expired adult/paediatric packs (n = 78); expired neonatal packs (n = 7). These four categories were further subdivided into medications and fluids (Figure 1).

The medications used most frequently from the adult/paediatric emergency packs were adrenaline and sodium bicarbonate (recorded on 52.8% and 41.5% of forms, respectively). Other medications were used considerably less often, with betamethasone never being used (Table I).

Regarding fluids from the adult/paediatric emergency fluid packs, Ringer's lactate was used most frequently, followed by sodium chloride 0.9%, dextrose 5% and hydroxyethyl starch (HES) (Table II). Darrow's half-strength solution was never used.

Adrenaline use was documented in only one of the four returned forms for the neonatal medicine packs; all 10 units of adrenaline were used. Atropine, naloxone and hydrocortisone were only

Table I: Medications used from the adult/paediatric emergency packs

Item	Total units used	Quantity in pack	Range used per occasion	Total forms returned for each unit used (n = 53)
				n (%)
Adrenaline 1 mg/ml	200	20	1–20	28 (52.8)
Sodium bicarbonate 8.5% 50 ml	39	3	1–3	22 (41.5)
Water for injection 10 ml	18	5	1–5	5 (9.4)
Dextrose 50% 50 ml	13	2	1–2	10 (18.9)
Calcium gluconate 10% 10 ml	10	1	1	10 (18.9)
Furosemide 20 mg/2 ml	10	5	2–5	3 (5.7)
Magnesium sulphate 2 g/2 ml	7	5	2–5	2 (3.3)
Naloxone 0.4 mg/ml	5	3	1	5 (9.4)
Atropine 0.5 mg/ml	4	5	1–2	3 (5.7)
Ipratropium bromide 0.5 mg	3	1	1	3 (5.7)
Dobutamine 250 mg/20 ml	2	2	1	2 (3.8)
Hydrocortisone 100 mg/2 ml	2	3	2	1 (1.9)
Amiodarone 150 mg/3 ml	1	2	1	1 (1.9)
Ipratropium bromide 0.25 mg	1	1	1	1 (1.9)
Isosorbide dinitrate 5 mg tablet	1	5	1	1 (1.9)
Lignocaine 2% 5 ml	1	5	1	1 (1.9)
Salbutamol 0.5% 20 ml	1	1	1	1 (1.9)
Betamethasone 3 mg/ml	0	5	0	0 (0)

Table II: Fluids used from the adult/paediatric emergency fluid packs

Item	Total units used	Quantity in pack	Range used per occasion	Total forms returned for each unit used (n = 28)
				n (%)
Ringer's lactate 1 000 ml	19	2	1–2	15 (53.6)
Dextrose 5% 200 ml	7	2	1	7 (25.0)
Sodium chloride 0.9% 200 ml	7	2	1–2	4 (14.3)
Sodium chloride 0.9% 1 000 ml	6	2	1	6 (21.4)
HES 6% 500 ml	4	1	1	4 (14.3)
Neonatalyte 200 ml	3	2	1	3 (10.7)
Darrow's half-strength 500 ml	0	2	0	0 (0)

HES – hydroxyethyl starch

Table III: Medications used from the neonatal emergency packs ($n = 4$)

Item	Total units used	Quantity in pack
Adrenaline 1 mg/ml	10	10
Atropine 0.5 mg/ml	1	5
Hydrocortisone 100 mg/2 ml	1	3
Naloxone 0.4 mg/ml	1	3
Adenosine 6 mg/ml	0	2
Calcium gluconate 10% 10 ml	0	2
Dextrose 50% 50 ml	0	2
Dobutamine 250 mg/20 ml	0	2
Furosemide 20 mg/2 ml	0	5
Lignocaine 2% 5 ml	0	5
Lignocaine 1% 20 ml	0	1
Magnesium sulphate 2 g/2 ml	0	5
Salbutamol 0.5% 20 ml	0	1
Sodium bicarbonate 4.5% 50 ml	0	3
Water for injection 10 ml	0	5

used once, while the other medicines in the neonatal pack were never used (Table III). There were no returned forms for fluids used from the neonatal emergency packs.

The total cost of expired medicines from the adult/paediatric emergency packs was R6 676.12 (US$440.96). The expired medication incurring the greatest cost, at R3 724.38 (US$246.00), was sodium bicarbonate with 57 wasted units. Although, numerically, more units of adrenaline expired (160 units), it is cheaper, so the total cost was lower (R584.00; US$36.32). The fluids that expired most frequently from the adult/paediatric emergency packs were, in descending order, Darrow's half-strength 500 ml, dextrose 5% 200 ml and sodium chloride 0.9% 1 000 ml. Darrow's, dextrose and HES contributed the highest costs in terms of wastage (Table IV).

The medications that expired most frequently from the neonatal emergency packs were, in descending order, sodium bicarbonate 4.5%, adrenaline, naloxone and lignocaine 2%, at a total cost of R1 244.15 (US$84.82). Here, wastage of sodium bicarbonate was notably more expensive than any other medicine. Only two fluids expired from the neonatal emergency fluid packs: dextrose 5% 200 ml and Neonatalyte 200 ml, at a total cost of only R40.02 (US$2.64) (Table V).

Overall, the total amount of money wasted as a result of expired medicines from all the emergency packs during the study period, was R7 960.29 (US$525.28). Of this total, 60.6% was from wastage of sodium bicarbonate (46.8% from sodium bicarbonate 8.5%;

Table VI: Expired medicines and associated costs from adult/paediatric emergency packs

Item	Total units	Price per unit	Total loss	Total in US$*
Adrenaline 1 mg/ml	160	R3.65	R584.00	US$38.57
Sodium bicarbonate 8.5% 50 ml	57	R65.34	R3 724.38	US$246.00
Darrow's half-strength 500 ml	48	R11.55	R554.40	US$36.32
Dextrose 5% 200 ml	38	R8.72	R331.36	US$21.89
Naloxone 0.4 mg/ml	30	R2.59	R77.70	US$5.13
Atropine 0.5 mg/ml	25	R4.62	R115.50	US$7.6
Sodium chloride 0.9% 1 000 ml	20	R8.27	R165.40	US$10.92
Ringer's lactate 1 000 ml	18	R8.67	R156.06	US$10.31
Furosemide 20 mg/2 ml	15	R13.02	R195.30	US$12.90
Magnesium sulphate 2 g/2 ml	15	R3.42	R51.30	US$3.39
Lignocaine 2% 5 ml	10	R1.39	R13.90	US$0.92
Ipratropium bromide 0.25 mg	8	R1.50	R12.00	US$0.79
Sodium chloride 0.9% 200 ml	8	R6.82	R54.56	US$3.60
Salbutamol 0.5% 20 ml solution	7	R21.16	R148.12	US$9.78
Ipratropium bromide 0.5 mg	6	R1.81	R10.86	US$0.72
Neonatalyte 200 ml	6	R11.29	R67.74	US$4.47
HES 6% 500 ml	5	R60.61	R303.05	US$20.02
Isosorbide dinitrate 5 mg tab	5	R0.18	R0.90	US$0.06
Water for injection 10 ml	5	R0.81	R4.05	US$0.27
Amiodarone 150 mg/3 ml	2	R46.21	R92.42	US$6.10
Calcium gluconate 10%	2	R6.56	R13.12	US$0.89
Betamethasone 3 mg/ml	0	R3.24	R0.00	US$0.00
Dextrose 50% 50 ml	0	R23.38	R0.00	US$0.00
Dobutamine 250 mg/20 ml	0	R36.98	R0.00	US$0.00
Hydrocortisone 100 mg/2 ml	0	R22.12	R0.00	US$0.00
Total			**R6 676.12**	**US$440.96**

*Based on the South African Rand to US Dollar exchange rate on 31 Dec 2019, HES – hydroxyethyl starch

Table V: Expired medicines from neonatal emergency packs and associated financial loss

Item	Total units	Price per unit	Total loss	Total in US$*
Sodium bicarbonate 4.5% 50 ml	18	R61.05	R1 098.90	US$72.58
Adrenaline 1 mg/mL	10	R3.65	R36.50	US$2.41
Naloxone 0.4 mg/ml	6	R2.59	R15.54	US$1.03
Furosemide 20 mg/2 ml	5	R13.02	R65.10	US$4.30
Lignocaine 2% 5 ml	5	R1.39	R6.95	US$0.46
Dextrose 5% 200 ml	2	R8.72	R17.44	US$1.15
Neonatalyte 200 ml	2	R11.29	R22.58	US$1.49
Salbutamol 0.5% 20 ml solution	1	R21.16	R21.16	US$1.40
Adenosine 6 mg/ml	0	R100.61	R0.00	US$0.00
Atropine 0.5 mg/ml	0	R4.62	R0.00	US$0.00
Bioplasma 50 ml	0	R252.56	R0.00	US$0.00
Calcium gluconate 10%	0	R6.56	R0.00	US$0.00
Dextrose 50% 50 ml	0	R23.38	R0.00	US$0.00
Dobutamine 250 mg/20 ml	0	R36.98	R0.00	US$0.00
Hydrocortisone 100 mg/2 ml	0	R22.12	R0.00	US$0.00
Lignocaine 1% 20 ml	0	R6.47	R0.00	US$0.00
Magnesium sulphate 2 g/2 ml	0	R3.42	R0.00	US$0.00
Potassium-free Neonatalyte	0	R36.46	R0.00	US$0.00
Sodium chloride 0.9% 200 ml	0	R6.82	R0.00	US$0.00
Water for injection 10 ml	0	R0.81	R0.00	US$0.00
Total			**R1 284.17**	**US$84.82**

*Based on the South African Rand to US Dollar exchange rate on 31 December 2019

13.8% from sodium bicarbonate 4.5%) and 7% from Darrow's half-strength 500 ml.

Discussion

This study showed the most common medications used from both the adult/paediatric and neonatal emergency packs at UAH were adrenaline and sodium bicarbonate. The medicines that expired most frequently were adrenaline, sodium bicarbonate and Darrow's half-strength solution.

Adrenaline is an essential component of cardiopulmonary resuscitation (CPR), so the finding in this study that its use was the highest of all the medications is expected.[6] Multiple units of adrenaline are often administered during CPR, initially as boluses and then as a continuous infusion after spontaneous circulation has been restored.[7] Wang et al.[8] found the average dose of adrenaline boluses used during CPR to be 8.1 mg, while adrenaline infusions are often made up by diluting 10 units of adrenaline in 0.9% saline.[9] Therefore, having 20 units of adrenaline in adult/paediatric emergency packs makes sense. On five occasions, all 20 units of adrenaline were used and on two occasions between 10 and 19 units of adrenaline were used. Although adrenaline was the medication that expired most frequently, with a similar number of units being used as expired, the cost of this wastage was low and justifiable considering the importance of always having adequate amounts of adrenaline immediately available for CPR. Furthermore, it is likely that the expired adrenaline was from emergency packs distributed to areas of low utilisation, for example outpatient departments, and redistribution of adrenaline ampoules close to their expiry date to areas of higher adrenaline use could have mitigated this wastage.

In the neonatal emergency pack, 10 units of adrenaline are provided. It was used only on one occasion during the study, which may be because adrenaline is readily available in the neonatal units as ward stock (personal communication, specialist neonatologist, 6 May 2020).

From the frequency of its use, it appears that sodium bicarbonate 8.5% was often given during CPR. The concurrent use of adrenaline and sodium bicarbonate was documented in 10/53 (18.9%) returned forms for adult/paediatric emergency medication packs. This is despite the routine use of sodium bicarbonate during CPR not being recommended and suggests possible overuse at UAH.[6] The latest ACLS guidelines recommend its use only in cases of severe hyperkalaemia or tricyclic antidepressant overdose.[10] The study design did not include indications for use of emergency medicines, so further study to investigate the rational use of sodium bicarbonate at UAH is required. As the medication contributing most towards financial losses from expiry, with the amount expiring exceeding the amount used, consideration should be given to reducing the number of units per pack from three to two, or even one; more could be obtained timeously from an adjacent clinical area on the rare occasions extra units are required.

Sodium bicarbonate 4.5% from the neonatal emergency packs was never used during the study period and was also the major

contributor to expired medicines from this type of pack. At UAH, sodium bicarbonate is very seldom used during a neonatal resuscitation and then only in the event of severe metabolic acidosis (personal communication, specialist neonatologist at UAH, 7 October 2020). Sodium bicarbonate is readily available in the neonatal wards and therefore the necessity of also keeping three units in neonatal emergency packs should be reviewed.

Amiodarone and lignocaine were each used only once during the study period. Nevertheless, these medicines are included in both the ACLS and the Pediatric Advanced Life Support (PALS) algorithms for cardiac arrest.[6,11] Therefore, these should be included in the adult/paediatric emergency packs, despite their low frequency of use. The amiodarone and lignocaine doses required for CPR also warrant that the quantities of both these medicines are not reduced below the current quantities in the packs. The cost of wastage of these medicines over six months was only R92.42 (US$6.10) for amiodarone and R13.90 (US$0.92) for lignocaine.

The only medication never used from the adult/paediatric packs was parenteral betamethasone. This is not unexpected, considering it is only indicated for the treatment of brain oedema due to tumour and to mature the lungs before delivery of preterm neonates. Both scenarios are urgent but not immediate emergencies and are treated in specific clinical areas of the hospital where ward stock should be available. Having betamethasone in every emergency pack is therefore questionable. Although never used, it is unclear why it was never recorded as expired as its shelf life (24 months) is not significantly longer than most other medications.

Atropine, dobutamine, hydrocortisone, naloxone, isosorbide dinitrate, salbutamol and ipratropium bromide were rarely used from the adult/paediatric emergency packs. This indicates that the quantity of these medicines included in emergency packs should be reviewed, as multiple units of most of these medicines are provided in each emergency pack. Furthermore, should more units be required, these could be obtained from a neighbouring clinical area's emergency pack.

With regard to fluids, Ringer's lactate was used approximately three times more often than any other fluid from the adult/paediatric emergency packs. This is to be expected as Ringer's lactate is a balanced crystalloid and is the first-line fluid for volume replacement.[12] It was used more often than sodium chloride, probably because large volumes of sodium chloride are no longer recommended for fluid resuscitation, given its effects on acid-base status.[12] However, both units of Ringer's lactate were used on only two occasions, and sodium chloride (1 000 ml and 200 ml) expired twice as often as used. This suggests the quantities of these fluids in the emergency packs could be reduced.

Neonatalyte is included in the adult/paediatric emergency packs, although it is a fluid tailored specifically to the metabolic needs of the neonate where it is used as a maintenance fluid.[13] It is not indicated for fluid resuscitation at any age.[3,13] The fluid shifts associated with this type of glucose-containing solution can even exacerbate intravascular hypovolaemia.[3] Therefore, it is unclear why Neonatalyte is included in the adult/paediatric emergency packs or why it was used on three occasions. It is possible that it was administered to treat hypoglycaemia in paediatric patients, as it contains 10% glucose, with Neonatalyte indicated in this scenario where dextrose 10% is unavailable. However, dextrose 50% is included in the emergency medication packs and can easily be diluted to a 10% solution; therefore, this need should not arise. In addition, Neonatalyte from the neonatal emergency packs was never used during the study period. Therefore, the inclusion of Neonatalyte in the adult/paediatric and neonatal emergency packs should be reviewed as it appears unnecessary and possibly detrimental if used inappropriately.

Darrow's half-strength is another paediatric maintenance fluid included in the adult/paediatric emergency packs, also not indicated for fluid resuscitation in a dehydrated child.[9] In this study, Darrow's half-strength was never used, was the fluid expiring most frequently and incurred the third highest financial loss of all the fluids included. Being available as ward stock in paediatric wards and ICUs, the inclusion of Darrow's half-strength in the adult/paediatric emergency packs should be reviewed.

The neonatal emergency packs were used infrequently during the study, with only 11 forms returned to the pharmacy and 4/15 of the medicines ever used. Consequently, it is not possible to draw definitive conclusions regarding the use of these packs.

Study limitations

There were several limitations to this study. Clinical indications leading to the emergency medicine packs being opened were not recorded so it cannot be determined if medicines were used appropriately. The hospital areas from where the emergency packs were returned could not be determined and therefore no associations could be made between specific clinical areas and the frequency of use of the emergency packs, or in which areas the emergency medicines most often expired. Due to the small sample of the neonatal emergency medicine packs, the recommendations made from this study based on these results, should be discussed with a neonatal specialist before any changes to these neonatal packs are implemented. Incomplete forms were returned to the pharmacy, leading to 18 (9%) being excluded from analysis. Consequently, some medicines could have been used but were not recorded.

Based on the findings, the following recommendations are proposed:

1. In the adult/paediatric emergency packs:
    - Dobutamine and sodium chloride (1 000 ml and 200 ml) can be reduced to one unit per pack.
    - Sodium bicarbonate 8.5% (50 ml) can be reduced to two units per pack.
    - Atropine, hydrocortisone and naloxone can be reduced to two units per pack.
    - Neonatalyte, Darrow's half-strength and betamethasone can be removed.

The price for the adult/paediatric emergency pack could then be reduced by 23.7%, from R891.97 (US$63.80) to R680.93 (US$48.71).

2. In the neonatal emergency packs, only the following medicines should be included:
   - Adrenaline, 10 units
   - Atropine, 5 units
   - Naloxone, 3 units
   - Sodium bicarbonate 4.5%, 2 units
   - Hydrocortisone, 1 unit
   - Calcium gluconate, 1 unit
   - Dextrose water 5% 200 ml, 2 units
   - Sodium chloride 0.9% 200 ml, 2 units
   - Sterile water for injection 5 ml, 5 units

The price of the neonatal emergency packs could then be reduced by 75.5%, from R1 151.91 (US$82.40) to R282.60 (US$20.21).

3. The emergency medicine packs should be returned to the pharmacy at least one month prior to expiration, to ensure that the medicines due to expire can be distributed to high-use areas before expiration.
4. Clinics and allied health departments within UAH should receive an abbreviated form of emergency medicine pack containing a reduced quantity of medicines. Patients visiting these clinical areas are generally in better health than patients admitted to hospital and life-threatening emergencies occur less frequently in these areas.

It would be important to determine whether these recommendations, if implemented, reduced costs without compromising patient care by repeating the study at a later time. In the interim, any deficiencies of medicines subsequently found in the emergency packs should be reported to the Hospital Resuscitation Officer to determine whether these should be immediately reinstated. A related area for future research is to investigate whether emergency packs are used appropriately in emergencies and for the correct indications.

Although the costs of wasted emergency medicines were low, if all hospitals of comparable size in South Africa instituted similar cost-saving methods, the total amount of money saved would be more significant. In the public healthcare sector in South Africa, limited resources and budgetary constraints are a reality. Any reductions in financial losses due to wastage would be beneficial and improve resources available for patient care.

Conclusion

Adrenaline was by far the emergency medicine used most frequently at UAH. Other medicines in the emergency packs were used considerably less frequently and some were not used at all, particularly those in the neonatal emergency packs.

The costs of expired medicines were relatively low but can be reduced further by reviewing the contents of the emergency packs and reducing the amount of and/or removing unnecessary medicines. Ensuring the return of unused medicines close to expiry and their redistribution to high-use areas before the expiration date would also reduce wastage.

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Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

The study was approved by the Health Sciences Research Ethics Committee of the University of the Free State (Ref: UFS-HSD2019/0008/2805) and by the Free State Department of Health. Informed consent was not required because no human subjects or patient information were involved in the study or required for data collection.

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