Research/Recherche

How important are airfreight rates and vaccine packaging in cost-saving efforts for the Expanded Programme on Immunization?

B. Schreuder,[1] H. Arentsen,[2] & M. Matosse[3]

Vaccines constitute the single most important cost factor in the Expanded Programme on Immunization (EPI) in Mozambique and in view of future new disease-control initiatives, the proportional expenditure on vaccines will only increase. Airfreight may contribute up to at least 25% of the total cost of delivered vaccine. Air transport of vaccine provided by UNICEF was arranged by the vaccine supplier. As a result of a lack of control mechanisms, airfreight rates were unnecessarily high and showed considerable variation. By negotiating rates directly with the airlines, the EPI management team in Mozambique succeeded in reducing them from an average of about US$ 12 per kg to US$ 4 per kg, equivalent to an annual saving of US$ 100000.

Vaccine vials are typically packaged in one of the following types of boxes: small colourful boxes containing 5–10 vials or bigger more functional boxes containing 50–100 vials. The packaging of vials in smaller boxes can double airfreight costs compared with bigger boxes. The EPI management team for Mozambique recommends that UNICEF should take over from suppliers the arrangements for shipping vaccine and negotiate airfreight rates centrally; further, WHO should tighten current vaccine-packaging standards for net packaging volume per dose, so that packaging in uneconomical small boxes can be eliminated.

Introduction

Immunization is perhaps one of the most effective and efficient ways of protecting the health of the world's children and women against a number of specific diseases (*1*, *2*). Since the end of the 1970s an increasing percentage of children have received vaccinations against poliomyelitis, tuberculosis, measles, diphtheria, pertussis, and tetanus. The impact of these efforts is mainly reflected in the control of epidemics and the decline of disease incidences, or even potential disease eradication.

The cost of vaccine determines to a great extent the cost of vaccination programmes, as it accounts for up to 35% or even more of total expenditure (*3*, *4*). It is expected that this proportion will increase as a result of new disease-control initiatives, intensified strategies for the eradication of poliomyelitis, and improvements in the quality of vaccines. The demand for vaccines is now more than 10 times higher than it was halfway through the 1980s.

Mechanisms to control the cost of vaccines can be divided into two main groups:

— initiatives to control the cost of production plus the cost of transport of the vaccine to the programme; and

— efforts to reduce the cost of storage, transport, and wastage at different levels in the programme, by stock-control systems, reducing the number of vaccination sessions, or maintaining open vials of vaccine between sessions.

In this article we will discuss mechanisms in the first of these groups, in particular the impact of airfreight rates and the type of packaging used on the cost of vaccines.

Vaccine procurement

Because of price, experience, and efficiency, the Expanded Programme on Immunization in Mozam-

[1] Chief Technical Adviser, EPI/MCH–DANIDA Project, CP751, Maputo, Mozambique. Requests for reprints should be addressed to this author.

[2] Formerly: Logistic Adviser, EPI/MCH–DANIDA Project, Mozambique.

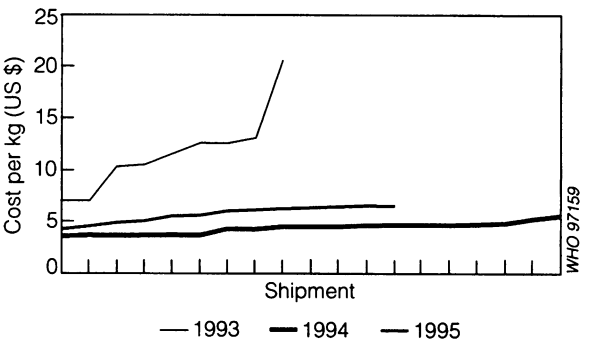
[3] National Manager, EPI, Mozambique.

Reprint No. **5783**

bique procures its vaccines through UNICEF Copenhagen. Orders are placed twice yearly, and all vaccines are shipped by air to Maputo, the capital. The total annual EPI expenditure on vaccines in Mozambique is currently about US$ 800000, including production costs, airfreight to Mozambique, and handling fees.

Vaccine prices are negotiated by UNICEF with suppliers. The terms and conditions of delivery are stipulated in UNICEF's standard purchase order, which specifies, for example, gross weight and dimensions of shipments and their number of packages. According to standard practice, prepaid insured airfreight is arranged by the supplier.[a]

Fig. 1. **Airfreight rates in US$ per kg chargeable weight, 1993–95.**



Costs of airfreight

The cost of airfreight is determined by the rate per kg and the weight of the shipment, as discussed below.

Airfreight rates

During the second half of 1993, EPI in Mozambique received a total of nine vaccine shipments, originating from Japan, Canada, and Australia, as well as various European countries. Average airfreight was US$ 11.68 per kg, with the lowest rate being US$ 7.02 per kg (origin, Germany) and the highest, US$ 20.56 per kg (origin, Japan).

Thus, airfreight rates are, in general, very high, but individual rates exhibit substantial variations.

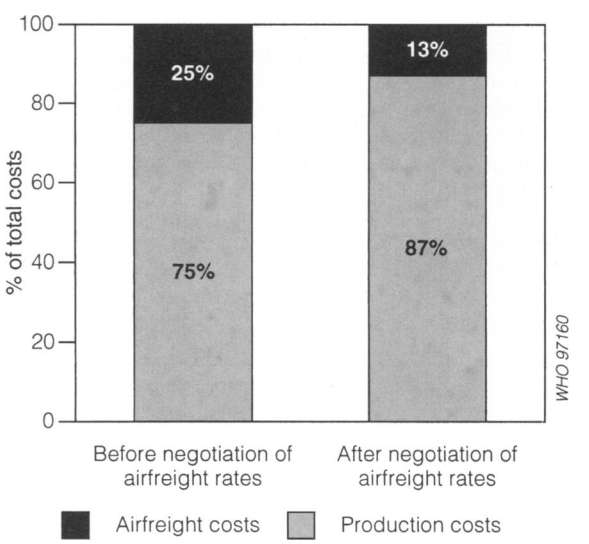
In an attempt to explain these variations, we first tested whether there was a direct relation between cost and distance shipped. This could, however, not be confirmed.

We then investigated the airfreight market by negotiating airfreight rates with the airlines. As a result we were able to obtain better rates than had been offered previously. We informed UNICEF of this and agreed with them to arrange vaccine shipments to Mozambique independently.

After 1 January 1994 EPI in Mozambique received vaccine shipments only on the basis of independently negotiated airfreight rates. The effect of this change is shown in Fig. 1. Rates were reduced from an average of US$ 11.68 per kg to an average of US$ 4.35 per kg. Not only were the rates lower but they also became much more stable. In 1995 the average airfreight rate increased to US$ 5.5 per kg. This was partly the result of a devaluation of the US$ and partly because one airline stopped flying to Maputo, reducing both competition and capacity.

Through negotiation of airfreight rates, the relative cost of freight was reduced from 25% to 13% of the total vaccine cost (Fig. 2), saving the Mozambique programme approximately US$ 100000.

Fig. 2. **Airfreight costs as a proportion of total costs, before and after negotiating airfreight rates.**



[a] UNICEF Purchase Order No. CCS 951741 reads, "The supplier shall arrange for prepaid insured AIR FREIGHT shipment to the consignee. Actual air freight charges (and insurance premium) should be added to the invoice as a separate item for refund by UNICEF."

Chargeable weight

Airfreight is normally charged according to weight. However, in the case of bulky shipments, i.e. where the volume exceeds a ratio of $6 m^3$ per tonne, the customer is charged for excess volume. The chargeable weight (in kg) is then calculated by dividing the volume in cubic metres by the weight in tonnes; in addition to the normal weight charge, volume in excess of $6 m^3$ per tonne is charged as a percentage (e.g. $6.6 m^3$ per tonne results in 10% surcharge).

Vaccine shipments can be bulky, and of the total charged weight of 9.5 tonnes billed in 1993, the equivalent of 0.9 tonnes of weight was charged for excess volume, i.e. 9.5% of the total charged weight. This excess volume cost the programme US$ 11 500.

Vaccine packaging

Packaging vaccine vials in boxes has two primary functions: to prevent them from breaking and to facilitate their distribution and handling. The charges for excess volume detailed above were reason to look further into the essentials of vaccine packaging. WHO has elaborated some standards for vaccine packaging (Table 1). In addition to the number of doses per vial, these norms refer to the maximum net volume per packaged dose. This volume includes the vaccine vial, the package containing the vaccine vials and any intermediate packaging material. Diluent and droppers need not be subject to the same norms, but should travel with the vaccine consignment whenever feasible.

We analysed the relation of net volume per packaged dose to chargeable weight, for the shipments of vaccines EPI Mozambique had received since 1992, using the following indicators:

— the type of antigen (i.e. the vaccine);

— the number of doses per vial;

— the net volume per packaged dose;

— the net weight per packaged dose;

— the gross volume per dose (i.e. as shipped);

— the gross weight per dose (i.e. the chargeable weight per dose, including any excess volume charges);

— the ratio of gross volume to weight; and

— the ratio of net weight to gross weight.

After the exclusion of certain shipments which could not be analysed for various reasons, average values of some of the above indicators for the remaining 48 shipments were calculated and are shown in Table 2. It was evident that the single packaging criterion for which WHO has established standards (i.e. net volume per packaged dose) was nowhere specified on the airway bill or on UNICEF's standard purchase order.

From the information shown in Table 2, it is evident that the gross weight per dose can be much higher than the net weight per dose. The required packaging in cartons and/or in cold boxes with ice easily doubles the weight of vaccine shipments. Reducing net packaging volume can significantly reduce the number of cold boxes required, and therefore the gross (or chargeable) weight.

Some of the vaccines were packed in small "fancy" boxes (often with colour printing), containing only 5 to 10 vaccine vials. This not only has a positive effect on volume and weight but also is more costly in terms of packaging material. The boxes used for packaging vaccine vials can be divided into two main groups:

Type A: Plain cardboard boxes, with a label indicating the name of the supplier, the lot number, the expiry date, etc. These boxes contain from 50 up to 100 vaccine vials without separating material.

Type B: Small "fancy" (colour-printed) boxes, indicating the name of the supplier, the lot number, the expiry date, etc. These boxes contain 5 to 10 vaccine vials with additional packing material separating each vial.

We analysed the impact of these two types of packaging on the gross volume per dose, the gross volume to gross weight ratio, and the chargeable weight per dose (Table 3). All three indicators showed substantial differences. These data revealed that, on average, the chargeable weight per dose of vaccine in type-B boxes was 146% higher (1.80/1.23). The gross volume was increased by 252% (9.68/3.83) and the volume to weight ratio was 171% higher (5.51/3.22).

We also analysed the potential impact of changing from type-B to type-A packaging on net, tare,

Table 1: **WHO-recommended packaging standards for selected vaccines**

Vaccine[a]	Doses/vial	Maximum packaging volume/dose (ml)
BCG	10–20	1.5[b]
DTP–TT	10	3.0
DTP–TT	20	2.5
Poliovirus (oral)	10	2.5
Measles	10	3.0

[a] DTP = diphtheria–tetanus–pertussis; TT = tetanus toxoid.
[b] Figures in this column include the vaccine vials, the box the vials are packaged in, and any intermediate packing material.

Table 2: **Averages of selected packaging indicators for 48 vaccine shipments to EPI, Mozambique**

Vaccine[a]	Doses/vial	Gross volume/ dose (cm^3/dose)	Net weight/ dose (g/dose)	Gross weight/ dose (g/dose)	Net weight/ gross weight (%)	Gross volume/ gross weight (g/cm^3)
BCG	20	4.67	0.48	0.83	58	5.57
DTP	10	8.34	1.05	1.94	54.2	4.30
Measles	10	19.74	1.18	3.51	33.7	5.63
Poliovirus (oral)	10	17.46	0.70	1.35	52.1	5.47
TT	10	6.64	0.88	2.01	44	3.29
All	—	9.48	0.86	1.93	44.6	4.88

[a] DTP = diphtheria–tetanus–pertussis; TT = tetanus toxoid.

Table 3: **Differences in selected packaging indicators for vaccine packaged in type-A or type-B packaging[a]**

	Chargeable weight/ dose (g/dose)		Volume/weight (ml/g)		Gross volume/ dose (ml)	
Vaccine[b]	Type A	Type B	Type A	Type B	Type A	Type B
BCG	0.47	0.97	4.09	6.37	1.93	6.18
DTP	1.79	2.12	3.89	5.00	7.50	10.56
Measles	—	3.65	—	5.10	—	19.06
Poliovirus (oral)	1.27	1.35	2.13	5.78	2.71	7.89
TT	1.40	2.25	1.33	4.40	2.56	9.87
All	1.23	1.80	3.22	5.51	3.83	9.68

[a] Type A packaging contains 50–100 vaccine vials per box; Type-B packaging contains 5–10.
[b] DTP = diphtheria–tetanus–pertussis; TT = tetanus toxoid.

and gross weight. For this purpose we used all shipments of BCG and poliovirus vaccine packed in type-B boxes that the programme had received in 1995. For some shipments, the programme was charged for excess volume. The dimensions of the type-B boxes were measured, and the boxes were weighed together with the vaccine vials. Then the dimensions of an empty type-A box were measured, and the box was filled with the same type of vials and weighed. Some of the results of these comparisons are presented in Table 4.

Net weight. The net weight of vaccine packaged in type-B boxes was 20% higher (817/708) for BCG vaccine and 15% higher (482/403) for poliovirus vaccine than the same quantity of vaccine packed in type A boxes.

Net volume. Type-B boxes increased the net volume of BCG vaccine shipments by a factor of 2.7; for poliovirus vaccine the increase was by a factor of 2.0 (data not shown). In other words, type-B boxes more than doubled the volume of vaccine shipments.

Table 4: **The impact of changing packaging type on net, tare, and gross weight**

Vaccine	Packaging type	Net weight (kg)	No. of cold boxes required	Tare weight (kg)	Gross weight (kg)	Tare weight/ gross weight	% Increase in gross weight
BCG	A	403	15	225	628	0.36	
	B	482	40	600	1082	0.55	72
Poliovirus (oral)	A	708	50	1042	1750	0.60	
	B	817	100	2084	2901	0.72	66
Both	A	1111	65	1267	2378	0.53	
	B	1299	140	2684	3983	0.67	67

Lower packaging volume means lower or even no charges for excess volume and also that considerably less space in central and provincial cold stores is needed. However, a reduction in net volume is mainly seen in the reduction of tare weight.

Tare weight. Vaccine (except for tetanus toxoid) is shipped in cold boxes with ice. The weight attributable to cold boxes and ice is the tare weight, and is the difference between the gross and the net weight. The effect on volume of type-B packaging is directly reflected in the number of cold boxes needed, and thus in the tare weight. Our calculations show that type-B packaging requires more than twice as many cold-boxes, with a tare weight more than twice as high.

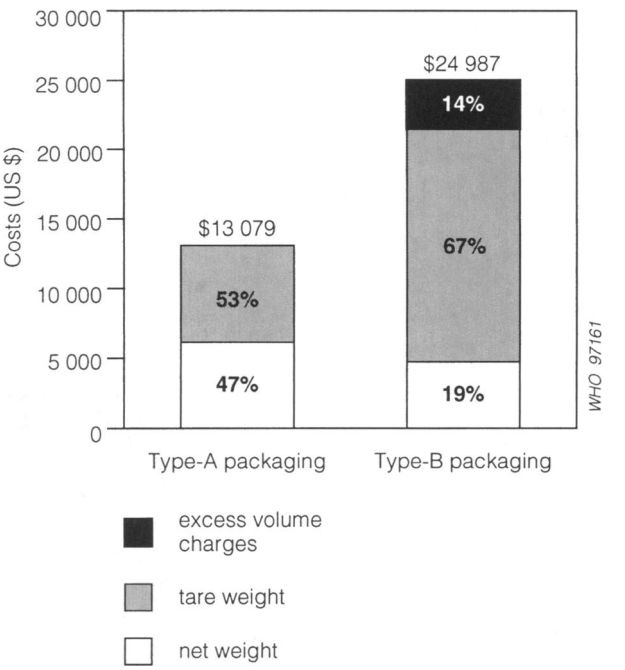
Gross weight. On average, the gross weight of type-B packaging was 67% higher than that of type-A packaging. The difference in gross weight between the two packaging types was slightly lower for poliovirus vaccine than it was for BCG vaccine.

Impact on freight costs. The airfreight costs for the annual shipments of the two vaccines in selected examples of the two packaging types are shown in Fig. 3. The airfreight costs of type-B packaging were almost twice as much as they would have been for the same vaccine shipped in type-A packaging. The major difference is attributable to the increase in tare weight (112%), which contributes 67% of the gross weight of the consignment.

Excess volume. Also shown in Fig. 3, type-B packaging resulted in excess volume charges of 14% for these two vaccines.

The cost savings the programme would have realized if BCG and poliovirus vaccines had been packed in only type-A boxes would have been nearly US$ 12000 (actual expenditure US$ 24987). These calculations assume an airfreight rate of US$ 5.5 per chargeable kilo.[b]

Fig. 3. **Annual airfreight costs for BCG and oral poliovirus vaccine for selected examples of the two packaging types.**



Net volume

As the net volume per packaged dose was not specified in the shipping contract, type-B boxes were collected over a period and the volume per box was calculated. Ten different examples of type-B boxes were obtained, whose calculated net volumes per dose are shown in Table 5. These data cover only a portion of vaccine shipments; moreover, because we tried to select packages at extreme ends of the range, these data are not representative.

However, in only two cases did packages not satisfy WHO standards — one was a small box containing 5 vials of measles vaccine; the other was a shipment of tetanus toxoid (TT) packed in a very large box (the same vials fit easily into another box 2.5 times smaller).

The packaging for oral poliovirus vaccine, although within WHO standards, was too bulky and resulted in a volume to weight ratio of 7.24, implying at least 20% excess volume charges. Although the vaccine was packaged in boxes of 10 vials, 15 vials fit easily into the same box.

Oral poliovirus vaccine. Since the cap of the oral poliovirus vaccine bottle used in the programme was unnecessarily large, and a packaging volume of less than 1.5 ml per dose would have resulted had type-A

[b] The 3- to 4-times-higher production costs of type-B boxes, and the cost of the additional cold boxes and ice are not taken into consideration in the above calculation. We did not verify the appropriateness of the technical specifications of the cold boxes in relation to hold-over time. In view of the substantial increase in tare weight as a proportion of gross weight due to type-B boxes, further analyses should be carried out.

Table 5: **Key packaging indicators for selected examples of type-B packaging**

Vaccine[a]	Doses/vial	Vials/box	Net packaging volume/dose (ml)
Measles	10	10	2.22
Measles	10	10	3.82
Measles	10	50	2.35
BCG	20	10	1.27
BCG	20	50	0.64
Poliovirus (oral)	10	10	2.25
TT	10	5	4.17
TT	10	50	1.72
TT	10	50	4.30
DTP	10	50	1.72

[a] TT = tetanus toxoid; DTP = diphtheria–tetanus–pertussis.

packaging been used, we think that the WHO norm for oral poliovirus vaccine (in plastic vials) can be tightened to less than 2 ml/dose.

TT and DTP vaccine. The TT and diphtheria–tetanus–pertussis (DTP) vaccine used, packaged with 50 vials per box, yielded a packaging volume of 1.72 ml per dose (WHO standard 3.0 ml per dose). As the packaging appeared adequate, the norm for TT/DTP 10-dose vaccine vials can probably be reduced to a maximum of 2 ml per dose.

BCG vaccine. The BCG vaccine used, packaged in a 50-vial box, resulted in 0.64 ml of packaging per dose, 42% of the WHO norm of 1.5 ml per dose. A standard of 1 ml per dose therefore seems feasible.

Measles vaccine. The only available sample of measles vaccine satisfying WHO standards had one of the highest tare volumes per dose relative to the other shipments of measles vaccine we received. Although we believe the WHO norm could be reduced to at least 2.5 ml per dose, this should be investigated more fully.

Conclusions

Airfreight rates and choice of packaging type are important for reducing the cost of vaccination programmes. The combined effect of negotiated air-freight rates and reducing chargeable weight by a reduction in net packaging volume can reduce freight costs by about 25%. Use of negotiated airfreight rates and type-A packaging for all the vaccines in EPI in Mozambique would yield, in real terms, annual savings of approximately US$ 118000 on a total annual expenditure on vaccines of US$ 800000. Furthermore, current WHO standards for net packaging volume per dose are not sufficiently tight to eliminate wasteful type-B packaging.

Recommendations

- UNICEF should take over the management of airfreight from vaccine suppliers and negotiate rates directly with the airlines. The cost of airfreight should be taken into consideration in the selection of vaccine suppliers for EPI.
- Vaccine packaging should be more functional. Small, colourful boxes that are expensive to produce should be eliminated. Vaccines should be packaged only in type-A boxes, of standard size, containing 50–200 vials each, and labelled with only the necessary information. WHO should tighten its standards for net packaging volume per dose in order to encourage this.

Acknowledgements

We would like to thank Michel Zaffran and John Lloyd, in particular, but also all the other individuals who supported us in writing this article.

Résumé

La réduction des frais de transport aérien et de conditionnement permettrait au Programme élargi de Vaccination de réaliser d'importantes économies

Les vaccins constituent le poste le plus coûteux du Programme élargi de Vaccination (PEV) au Mozambique, et compte tenu des nouvelles initiatives qui se préparent en matière de lutte contre la maladie, leur poids relatif dans le budget ne peut qu'augmenter. Le transport aérien peut représenter 25% et plus du coût final du vaccin. Jusqu'à maintenant, le transport des vaccins fournis par l'UNICEF était organisé par les fabricants. Du fait de l'absence de mécanismes de contrôle, les tarifs de fret aérien étaient excessifs et très variables. En négociant directement avec les compagnies aériennes, les administrateurs du PEV au Mozambique ont réussi à les faire baisser de US$ 12 à US$ 4 par kg en moyenne, ce qui représente une économie de US$ 100000 sur un an.

Normalement, les flacons de vaccin sont emballés dans deux types de boîtes: de petites boites colorées contenant 5 à 10 flacons, ou de grandes boîtes plus fonctionnelles de 50 à 200 flacons. Le coût de transport par avion des premières peut être le double de celui des secondes. Les administrateurs du PEV au Mozambique recommandent que l'UNICEF se substitue aux fournisseurs pour organiser l'expédition et centralise la négociation des tarifs avec les compagnies aériennes. En outre, l'OMS devrait adopter des normes de conditionnement des vaccins plus sévères en ce qui concerne le volume net par dose après conditionnement, de façon à éviter l'emploi de petites boîtes antiéconomiques.

References

1. **World Bank.** *World development report, 1993. Investing in health.* New York, Oxford University Press, 1993.
2. **Lee K, Mills A.** *The economics of health in developing countries.* Oxford, Oxford University Press, 1983.
3. **Brenzel L, Claquin P.** Immunization programs and their costs. *Social science and medicine*, 1994, **39**: 527–536.
4. *Joint review report on EPI in Tanzania* (selected appendices prepared by R. Feilden). United Republic of Tanzania Ministry of Health and DANIDA, 1987.
5. *Guidelines on the international packaging and shipping of vaccines.* Geneva, World Health Organization, 1992. Unpublished document EPI/CCIS/81.4 Rev.5 (available on request from Global Programme on Vaccines, World Health Organization, 1211 Geneva 27, Switzerland).