Frequency and causes of vaccine wastage

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Abstract

Assessing the frequency of vaccine wastage and the relative magnitude of its various causes may help to target efforts to reduce these losses and to husband funds for increasingly expensive vaccines. Methods: As a preliminary overview of wastage in the United States, 64 public-sector state and local health department immunization programs were polled in 1998 and 1999 for wastage recording practices. Actual wastage data were collected from a non-random subset of five states. Data on returns of wasted vaccine to manufacturers were analyzed from routine national biologics surveillance and from an ad-hoc survey. Excise tax credit requests for such returns between 1994 and 1999 were reviewed. Results: Rates of wastage among the five states ranged from about 1 to 5% in 1998, with an overall rate of 2.6% among 57 immunization programs in 1999. Categories of wastage used by the health departments varied widely, with overlapping classifications. The major causes appeared to be refrigeration (cold chain) lapses, followed by expiration. Overall rates of vaccine returns varied up to 8% by manufacturer, and from 1 to 50% by vaccine type, with higher return rates generally found for lesser-used vaccines. Conclusions: If these wastage estimates of 1–5% applied nationally, in 1998 there would have been approximately US$6–31 million worth of unused vaccine in the public sector alone. The two most common forms of wastage reveal the potential value of developing vaccines with improved heat stability and longer shelf lives. We propose six main classifications of vaccine wastage for use in routine monitoring and reporting. Published by Elsevier Science Ltd.

Keywords: Wastage; cold chain; Expiration

1. Introduction

Vaccine wastage may result from a variety of causes, such as (a) expiration before usage can occur; (b) heat (or freezing) damage due to breaks in the “cold chain” when vaccine is left out of refrigeration or cooling/insulating equipment fails; (c) physical damage due to crushing, dropping, or loss of label; (d) losses in transit or inventory; and (e) incomplete use of the nominal number of doses in multi-dose vials, among other reasons (vaccination of individuals already immune or not recommended for vaccination is outside the scope of this paper). Scant data are available about the nature and extent of vaccine wastage in the United States and other developed countries. A study in Canada reported that the cost of wasted vaccine comprised 3.3% of an annual provincial vaccine budget [1]. In Australia, a survey revealed much wastage of BCG [2] (vaccine abbreviations used in this paper are explained in footnote to Table 3). cold chain studies in the United States and abroad have uncovered worrisome deficiencies in vaccine storage and handling practices, raising concern for the high number of vaccine doses at risk of being damaged and wasted [3,4].

Somewhat more data on vaccine wastage are available for the developing world. The World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF) have estimated overall wastage rates in developing countries of around 50% [5–8]. In Indonesia in 1995–1996, 36% of hepatitis B vaccine doses used in the Expanded Program on Immunization (EPI) were discarded [9]. In national immunization days in 1993 to eradicate polio in Egypt,
around 25% of OPV doses in 20- and 50-dose vials were wasted in urban fixed-site vaccination centers, as well as in both urban and rural house-to-house campaigns [10]. In rural fixed sites, 41.5% of multi-dose-vial doses were wasted.

The US Centers for Disease Control and Prevention (CDC) provides federal monies for vaccine purchase, product distribution, and immunization infrastructure for state and local health agencies. In 1998 alone, US$ 618 million was spent purchasing 62 million doses of vaccine for this purpose. We surveyed and analyzed existing records indicative of vaccine wastage in both the public and private sectors in the US in order to quantify and classify its different forms and to estimate the magnitude of the wastage problem.

2. Methods

2.1. State and local immunization program data

An invitation was sent in October 1998 to all 64 state, local, and territorial public immunization programs receiving Federal immunization grants in the US to participate in a survey for the types of wastage data they collected and maintained on the vaccine they distributed in their jurisdiction. A questionnaire also asked whether the data was maintained in computer databases or in paper records, and whether it was kept at the state or local (county, city) levels. Actual wastage data for the 1998 period were subsequently collected from a convenience sample of five state immunization programs (to be identified only as A, B, C, D, and E) in four regions of the United States, based on their willingness to participate and their categorization of wastage by specific causes.

For 1999, a national immunization program management survey solicited data from the 61 programs which were eligible to distribute vaccines purchased under the Vaccines for Children (VFC) program for entitled children. The survey form requested numbers of vaccine doses in their January and December 1999 inventories, doses distributed from the state or central level to providers and subsidiary health departments, and doses wasted during the year. CDC records were reviewed for doses purchased in 1999 by these programs under CDCs national vaccine contracts with manufacturers.

The Federal VFC program, started in 1994 and administered by CDC, provides states and territories with publicly-purchased vaccines at no charge for both public and private clinics for use in children 0–18 years of age who are either Medicaid eligible, have no health insurance, are under-insured (for immunization), or who are American Indian or Alaskan Native. 1

2.2. Ad-hoc survey of vaccine manufacturer returns data

All manufacturers marketing vaccine in the US were solicited to provide data on vaccines returned by providers for replacement or for excise tax credit. Two vaccine manufacturers, referred to as F and G, cooperated with this ad-hoc survey by providing data on vaccine doses returned for replacement, credit, or excise tax refunds, from both private and public providers, for the calendar year 1998. Their responses included returns data both for vaccines in the recommended childhood immunization schedule, as well as for non-routine and adult vaccines such as INF, HAV, and Td.

In general, vaccines purchased by the private sector can be returned for any reason to the manufacturer for replacement or credit towards new purchases. On the other hand, vaccines purchased at federal contract discount prices in the public sector do not have privileges for manufacturer replacement or purchase credit if wasted. However, they may be returned for credit of the federal excise tax paid (which finances the national vaccine injury compensation program). 2 The excise tax applied in 1999 and 2000 for specified vaccines was US$ 0.75 for each distinct disease prevented by the vaccine (e.g. US$ 0.75 for HIB, US$ 1.50 for HIB–HBV, US$ 2.25 for DTPa, and US$ 3.00 for DTPa–HIB).

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2.3. Biologics surveillance data

In voluntary cooperation with vaccine manufacturers, CDC has maintained since 1962 a system of national surveillance on the number of doses of vaccine and other biologics (e.g. immunoglobulins) distributed in both the public and private sectors in the US, as well as the number of doses returned unused [11]. Routine, existing unpublished data in this system for the period from January through December 1998 for two manufacturers (F and H) were analyzed and compared with corresponding data from the ad-hoc survey described above. Biologics surveillance data from six other manufacturers (G, I, J, K, L, M) could not be analyzed to determine a rate of vaccine returns because of incomplete data or non-reporting.

2.4. Federal excise tax credits

Requests to manufacturers by immunization programs for credit of federal vaccine excise taxes paid for wasted federally-funded vaccine were analyzed for the period 1994 through 1999, based on copies of the requests filed with CDC. The value of unclaimed tax credits was calculated by applying vaccine-specific tax rates for Federal vaccine doses reported wasted.

1 www.cdc.gov/nip/vfc/about.htm.
2 http://bhpr.hrsa.gov/vicp.
2.5. Wastage rate calculations

2.5.1. State and local immunization program data (~1998)
For the five sampled states, the “numerator” of the wastage rate was the absolute number of doses wasted for any given reason. The “denominator” was the corresponding number of doses distributed by the state program to its providers during the same time period. These time periods did not always coincide among these states due to variations in data availability. States A and B provided 1 year of data (January–December 1998), as did state D (September 1997–August 1998). States C and E provided 6 months of data (June–November 1998). For specific causes of wastage reported here, the rate numerator was the total number of doses wasted in states reporting wastage, if any, by that specific cause.

2.5.2. Management survey data (1999)
The wastage rate numerator was as described above. The denominator was the number of “doses handled”, calculated as the number of doses reported on hand in state or central state inventory in January 1999 + the number of doses purchased under Federal CDC national contracts in 1999 – the number of doses remaining on hand in December 1999. In cases where inventory data was missing or incomplete, or significant numbers of doses were purchased directly from manufacturers outside of CDC contracts, the wastage rate denominator was the number of doses reported distributed.

2.5.3. Vaccine manufacturer returns data
For a given vaccine, the numerator of the “returns” rate was the absolute number of doses reported by the manufacturers as returned for all causes for both public and private purchasers of vaccine. The denominator was the gross number of doses of that vaccine reported distributed in the same time period to all purchasers. This method was used to calculate manufacturer returns rates for both the ad-hoc survey as well as for data collected in routine biologics surveillance.

3. Results

3.1. Immunization program wastage
Out of the 64 state, 47 (73%), local, and territorial immunization programs returned the 1998 questionnaire. All programs collected data on the number of doses their sub-jurisdictions (i.e. county and city health departments) supplied to public and private providers (Table 1). There was considerable variation in the types and specificity of data collected regarding vaccine wastage. In general, state programs required their public providers (county and municipal health departments and their immunization clinics) to report more comprehensive information on vaccine utilization than their private providers (private physicians and health maintenance organizations).

Among the five states providing detailed data, the overall rates of vaccine wastage for all causes varied from 1.4 to 5.3% (Table 2). States had overlapping and incompatible classifications of wastage that did not permit uniform national summary statistics by wastage category (Fig. 1). There were 17 different classifications used by the five states, and several were not mutually exclusive. “Spoiled/lost/other” and expiration were the most common specific causes of vaccine wastage, affecting 2.64 and 0.86%, respectively.
Table 2
Summary of reported vaccine wastage in five US states (1997–1998) a

<table>
<thead>
<tr>
<th>State (region)</th>
<th>Population b (million)</th>
<th>Time period</th>
<th>Vaccine supply policy c</th>
<th>Doses distributed d</th>
<th>Doses expired (%)</th>
<th>Doses spoiled/lost/other (%)</th>
<th>Total doses wasted (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (SW)</td>
<td>4.7</td>
<td>January–December 1998</td>
<td>VFC, UI</td>
<td>1,285,848</td>
<td>24,123 (1.9)</td>
<td>43,794 (3.4)</td>
<td>67,917 (5.3)</td>
</tr>
<tr>
<td>B (Eastern)</td>
<td>1.2</td>
<td>January–December 1998</td>
<td>U</td>
<td>474,823</td>
<td>9415 (2.0)</td>
<td>2691 (0.6)</td>
<td>12,106 (2.5)</td>
</tr>
<tr>
<td>C (Eastern)</td>
<td>18.2</td>
<td>June–November 1998</td>
<td>VFC, UI</td>
<td>1,436,216</td>
<td>21,099 (1.5)</td>
<td>8450 (0.6)</td>
<td>29,549 (2.1)</td>
</tr>
<tr>
<td>D (Central)</td>
<td>19.8</td>
<td>September 1997–August 1998</td>
<td>VFC, UI</td>
<td>5,448,569</td>
<td>10,401 (0.4)</td>
<td>79,795 (1.5)</td>
<td>99,196 (1.8)</td>
</tr>
<tr>
<td>E (NW)</td>
<td>5.7</td>
<td>June–November 1998</td>
<td>U</td>
<td>1,156,496</td>
<td>10,428 (0.9)</td>
<td>5393 (0.5)</td>
<td>15,821 (1.4)</td>
</tr>
<tr>
<td>Total</td>
<td>49.6</td>
<td></td>
<td></td>
<td>9,804,152</td>
<td>84,466</td>
<td>140,123</td>
<td>224,589</td>
</tr>
</tbody>
</table>

a Time periods vary among the five states and do not reflect 2 full years of data.
c VFC: Vaccines for Children program, federally-purchased vaccine supplied to eligible children in private care only; UI: public vaccine supplied to children without insurance coverage for vaccinations; U: universal policy, state offers all vaccines recommended by the CDC Advisory Committee on Immunization Practice to all providers for all children.
d Denominators used were doses distributed from central inventory at state level.
e Total for five states are not adjusted for differing time periods, populations, or other demographic differences among them.

of doses in the corresponding states. In addition to cold chain spoilage classified under “spoiled/lost/other” in states A and B, an additional 0.62% of doses were reported wasted in more specific classifications involving the cold chain: “spoiled after receipt...” with or without negligence (state C), “refrigerator/freezer left open” (state E), “equipment/power failure” (states C, D and E), “left out of refrigeration” (states D and E), “damaged during shipment” (state E), and “frozen or contaminated” (state D). Almost as frequent as expiration as a cause for wastage was “unaccounted for” vaccine (0.74%). Doses wasted in categories such as “vial damage” and “insufficient doses in vial” (state D) were uncommon. Even rarer were doses wasted for reasons of “prepared too many doses”, “refused/spit out”, and “missing label”.

All 61 VFC-eligible immunization programs returned the 1999 program management survey form. Of these, 57 (93%) contained analyzable data on doses wasted. Rates of wastage among these 57 programs ranged from a low of 0.6 to a high of 6.8% (mean = 3.0%, median = 2.5%) (Table 3). Pooling the numerators and denominators of these 57 programs yielded an overall national, public-sector wastage estimate of 2.6%. Wastage by specific vaccine type varied from 1.1% (HBV) to 44% (MEA).

3.2. Manufacturer returns

Rates of vaccine returns to manufacturers, determined from both the ad-hoc survey as well as routine national biologics surveillance by CDC, varied from 0.5 up to 7.9%,
Table 3
Vaccine doses reported wasted, by vaccine type, among 57 VFC-eligible state and local immunization programs responding to a program management survey in United States (1999)\(^a\)

<table>
<thead>
<tr>
<th>Vaccine type</th>
<th>Doses wasted</th>
<th>Doses handled</th>
<th>Wastage rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT</td>
<td>83,959</td>
<td>321,536</td>
<td>26.1</td>
</tr>
<tr>
<td>DTP(_a)</td>
<td>187,637</td>
<td>10,878,429</td>
<td>1.7</td>
</tr>
<tr>
<td>DTP(_{a–HIB})</td>
<td>81,765</td>
<td>681,732</td>
<td>11.9</td>
</tr>
<tr>
<td>HAV</td>
<td>20,105</td>
<td>1,209,086</td>
<td>1.6</td>
</tr>
<tr>
<td>HBV</td>
<td>138,159</td>
<td>12,644,525</td>
<td>1.1</td>
</tr>
<tr>
<td>HIB–HBV</td>
<td>67,837</td>
<td>2,071,564</td>
<td>3.3</td>
</tr>
<tr>
<td>HIB</td>
<td>167,174</td>
<td>5,759,607</td>
<td>2.6</td>
</tr>
<tr>
<td>INF</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>IPV</td>
<td>86,200</td>
<td>5,077,778</td>
<td>1.5</td>
</tr>
<tr>
<td>MDA</td>
<td>10,961</td>
<td>25,031</td>
<td>43.8</td>
</tr>
<tr>
<td>MMR</td>
<td>99,185</td>
<td>7,971,837</td>
<td>1.3</td>
</tr>
<tr>
<td>MUM</td>
<td>49</td>
<td>156</td>
<td>31.4</td>
</tr>
<tr>
<td>OPV</td>
<td>423,825</td>
<td>5,036,344</td>
<td>8.4</td>
</tr>
<tr>
<td>PNU(_{ps-23})</td>
<td>48,395</td>
<td>268,106</td>
<td>18.1</td>
</tr>
<tr>
<td>RUB</td>
<td>251</td>
<td>648</td>
<td>3.6</td>
</tr>
<tr>
<td>Tb</td>
<td>87,891</td>
<td>4,240,152</td>
<td>2.1</td>
</tr>
<tr>
<td>VAR</td>
<td>55,809</td>
<td>3,327,547</td>
<td>1.7</td>
</tr>
<tr>
<td>Total</td>
<td>1,579,394</td>
<td>60,532,556</td>
<td>2.6</td>
</tr>
</tbody>
</table>

\(^a\) Data reported from 57 immunization programs responding with analyzable data for calendar year 1999 to a program management survey among 61 VFC-eligible state and local health departments. Data include both VFC and non-VFC publicly-purchased vaccine.

### Table 4
Reported vaccine doses distributed and returned, and rates of return to manufacturers (F–J) \(^a\) (1998) by ad-hoc survey and routine national biologics surveillance \(^b\)

<table>
<thead>
<tr>
<th>Data source manufacturer</th>
<th>Biologics surveillance</th>
<th>Ad-hoc survey</th>
<th>Biologics surveillance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>F</td>
<td>G</td>
</tr>
<tr>
<td>Total doses returned</td>
<td>766,921</td>
<td>619,307</td>
<td>122,806</td>
</tr>
<tr>
<td>Total doses distributed</td>
<td>38,334,402</td>
<td>34,730,088</td>
<td>26,227,442</td>
</tr>
<tr>
<td>Return rate (%)</td>
<td>2.0</td>
<td>1.8</td>
<td>0.5</td>
</tr>
</tbody>
</table>

\(^a\) Three additional US vaccine manufacturers/distributors (K–M) did not provide any data.

### Table 5
Comparison of routine biologics surveillance with ad-hoc survey data from manufacturer F revealed similar overall rates of returns, 2 and 1.8%, respectively. Among individual vaccines from manufacturer H, returns of DT, DTP\(_a\), and DTP\(_{a–HIB}\) were the highest at 38, 31, and 16%, respectively.

### Table 6
A comparison of routine biologics surveillance with ad-hoc survey data from manufacturer F revealed similar overall rates of returns, 2 and 1.8%, respectively. Among individual vaccines from manufacturer H, returns of DT, DTP\(_a\), and DTP\(_{a–HIB}\) were the highest at 38, 31, and 16%, respectively.
3.3. Excise tax credits

During the 6 years (1994–1999), a total of US$ 7,908,167 in credits were requested by 51 state and local immunization programs for Federal excise tax paid on wasted vaccine. The least amount was claimed in 1994 (US$ 52,751), and the most in 1996 (US$ 3,058,473). Comparing the credits claimed in 1999 (US$ 572,691) with the 1,602,933 doses reported wasted in that year by all 63 programs (whether VFC-eligible (Table 3) or not), revealed an additional US$ 1,473,155 of tax paid that was foregone by failing to return wasted doses and to file claims therefor.

4. Discussion

This preliminary look at vaccine wastage revealed a point estimate of 2.6% among all public-sector immunization programs, and rates from about 1 to 5% in five geographically dispersed states. Such rates must be underestimates, as it is likely many unused vaccine doses are never reported, nor returned to health departments for excise tax credit. The data suggest that refrigeration failure and product expiration are the most common causes of vaccine wastage. But because wastage classifications are not uniform, it is difficult to rank specific causes of wastage by their relative frequencies and to make comparisons among states. For example, some states use a combined category such as “spoiled/host/other” to classify all wastage other than expiration. Other states used quite specific categories such as “frozen/contaminated”, “prepared too many doses”, or “refused/spit out”.

Wastage rates by vaccine type reported from immunization programs varied markedly (Table 3), with the trends for specific antigens consistent with the frequencies of vaccines returned to manufacturers (Fig. 2). Less often used vaccines tended to have higher rates of wastage and return, around 30–50%, such as MEA (134,909 net doses distributed nationally in 1998; 25,031 “handled” by public programs in 1999), MUM (∼44,000 national doses in 1998; 156 public doses in 1999), and MUM–RUB (4,236 national doses in 1998). More commonly-used, high-volume vaccines tended to have lower rates, around 1–2%, such as HBV (34 million national doses in 1998) and MMR (14 million national doses in 1998).

The vaccine return rates found, 0.5–7.9% by manufacturer, are likely also an underestimate of true wastage.
Wasted vaccine in the private-sector is not always returned, even with replacement privileges. In the public-sector, we found only a small proportion of wasted vaccine was returned for Federal excise tax credit (~28% in 1999), leaving approximately US$ 1.5 million in unclaimed credits that could have been used to defray the increasingly higher costs of vaccine purchase.

There were several important methodologic limitations of the study. Already mentioned above was the variety of wastage classification schemes. For example, a dose wasted in state E because a refrigerator or freezer was inadvertently “... left open” would have been counted in state A or B in a much less specific catch-all category of “lost/spoiled/other”, which includes causes other than cold chain lapses. Other differences in routine data collection procedures and in immunization policies prevent direct comparisons of wastage rates between states, as well as between public and private providers within states. Some states distribute publicly-purchased vaccines to enrolled private providers only for children entitled by the VFC program. Other “universal” states distribute vaccine free of charge to all providers for all children in their state.

Another limitation was the difference in reporting periods for the five states contributing the data around 1998, which may have been affected by seasonal variation in vaccine purchase and usage. Also, these five states—constituting only 18% of the US population—were selected non-randomly and may not be representative, precluding extrapolation of their rates to the US as a whole. Lacking was information on wastage due to multi-dose vials, as well as the numbers of vaccines unaccounted for due to inventory “shortage” or even misappropriation. In addition, there is likely a large degree of under-reporting of wastage by providers.

A weakness in the returns analysis is that some manufacturers did not participate in the ad-hoc survey, or even in routine CDC biologics surveillance (Table 4). Moreover, comparison of rates between manufacturers is difficult because of differences in the types of vaccines they distribute, as well as variation in their policies and procedures governing returns. Finally, some manufacturers do not furnish reasons for the return of vaccine, nor its geographic origin, nor the public-versus-private status of the provider returning it. Similar lack of information on the reason for returns occurs in excise tax credit requests for federally-funded vaccine filed with the manufacturers and copied to CDC.

This preliminary study of vaccine wastage fills a vacuum on the subject in the US. There are studies of vaccine storage and handling, however, which reveal potential causes for significant amounts of vaccine wastage. Among 221 private provider offices visited in the state of Georgia, fewer than half maintained daily temperature logs for all cold storage units containing vaccines, thus, placing them at greater risk for not detecting storage temperatures outside of acceptable ranges [3]. Among 50 pediatric practices in Los Angeles, 84% of vaccine coordinators were unable to cite appropriate storage temperatures for vaccines, and 36% were unaware that freezing was harmful [4].

Such weaknesses in maintaining the cold chain probably result in inadvertent use of subpotent vaccine. This not only puts the unprotected recipient at risk of disease, but also means the actual wastage escapes detection. One measles outbreak in New York in the 1970s was attributed to vaccines that were improperly stored in the door of a refrigerator [13]. There are no more recent reports in the US of similar harm to patients, but the economic losses and potential for medical consequences resulting from mishandled vaccine have been noted [14,15].

Vaccine failure in the developing world has also been attributed to mishandling [5]. Polio outbreaks in South Africa may have resulted from vaccine damaged by cold chain breaks. A cold chain study in Hungary found that 4% of vaccines were “compromised” by summer heat and 38% by winter freezing [17]. It is estimated that widespread implementation of vaccine vial monitors that would detect improper storage temperatures could potentially result in annual savings of US$ 4.8 million for the EPI [18].

One form of wastage of potentially large magnitude, rarely studied and little recognized, is associated with the use of multi-dose vaccine vials. One study estimated that vaccine wastage costs associated with the use of multi-dose vials ranged from US$ 0.16 to 0.59 per dose administered [7]. Although the costs per dose for multi-dose vials are substantially less than for single-dose ones, their apparent savings may be illusory when fewer than their nominal number of doses are ever administered. This may occur when providers overfill syringes and then adjust the proper volume by squirting away the excess. One study in Indonesia of 10-dose vaccine vials determined an average of 2.6 doses per vial were wasted using disposable syringes [19].

A common misconception among providers is that multi-dose vials must be discarded within a certain time period after opening [20], which leads to avoidable wastage. In fact, remaining doses from partially-used, multi-dose vials may be administered in subsequent immunization sessions until the expiration date of the vial, provided that handling and cold storage criteria have been met. For the developing world, WHO estimates that adherence to this opened-vial policy has the potential to reduce wastage rates by up to 30%, resulting in annual worldwide savings of US$ 40 million in vaccine costs [21].

The total value of vaccine wasted in the US may be substantial. Applying a wastage range of about 1–5% as estimated in this study to public-sector vaccine purchases in 1998 (US$ 618 million) suggests an annual loss of US$ 6–31 million. Moreover, these amounts do not include wastage of privately-purchased vaccine doses, which are more expensive and comprise roughly half the US market [22]. As new vaccines are incorporated into the childhood...
immunization schedule [23], the value of wasted vaccine will likely increase. New vaccines are generally more expensive than older ones. For example, as of 31 October 2001, the Federal contract discount price per dose was US$ 45.99 for the new PNUv7 vaccine licensed for children in 2000, and was US$ 39.14 for 1995-licensed VAR. This compares with US$ 15.53 for MMR, first licensed in 1971 (private-sector “catalog” prices for PNUv7, VAR, and MMR were US$ 58.75, 49.13, and 28.35, respectively.)

The predominance of wastage due to refrigeration problems and to passage beyond the expiration date indicate the potential value of research and development of vaccines which are more tolerant of heat and which maintain their potency over longer shelf lives. Use of algorithms for vaccine selection and procurement that recognize the economic value of such wastage-reducing and cost-saving features of improved vaccines might provide market incentives for such innovations by industry [22,24].

Although some degree of vaccine wastage may be unavoidable, systematic efforts by immunization programs, vaccination clinics, and private providers to monitor and reduce it would be worthwhile. But first, better methods and data are needed to accurately and comprehensively measure the phenomenon, using both routine reporting and surveillance systems, as well as ad-hoc prospective studies in sentinel warehouses and clinics. Such special studies would be essential for the difficult-to-measure wastage associated with multi-dose vials. A uniform system for classifying and reporting vaccine wastage would be useful. Table 5 represents a preliminary proposal for such a classification.

Accurately and consistently quantifying the specific causes of wastage could help rethink immunization practices and policies, and better target wastage reduction efforts to achieve the most cost savings. The goal should be to make all doses count towards the success of immunization in protecting health.

Table 5
Proposed classifications of vaccine wastage

1. Expired vaccine
2. Refrigeration failure
   2.1. Shipment problem
      2.1.1. Delay beyond “cold life” of packaging
      2.1.2. Improper packaging during shipment (insufficient coolant or insulation)
   2.2. Vaccine stored at improper temperature (too cold, too warm)
      2.2.1. Refrigerator or freezer not set to improper temperature
      2.2.2. Faulty refrigerator or freezer
      2.2.3. Power outage
      2.2.4. Refrigerator or freezer door left open
   2.3. Vaccine left out of refrigeration in immunization provider’s office
4. Other: specify
   4.1. Discarding of unused doses in opened multi-dose vials
   4.2. Insufficient doses remaining after prior doses removed
5. Unused after vaccine removed from vial
   5.1. Changed intent to vaccinate (MD or RN)
   5.2. Changed intent to be vaccinated (patient or parent)
   5.3. Prepared too many doses
   5.4. Uncertain identity of vaccine in syringe or injection cartridge
   5.5. Not retained after administration (oral dose spit out or vomited, parental dose leaked out, intranasal dose sneezed out)
   5.6. Other: specify
6. Lost or missing
   6.1. In shipment/transit
   6.2. In inventory
   6.3. Other: specify
7. Other: specify

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