

Disease eradication, elimination and control: the need for accurate and consistent usage

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This article seeks to clarify the terminology associated with disease control, elimination and eradication programmes. There are several global activities under way, which are initiated and guided by resolutions of the World Health Assembly. Scrutiny of the feasibility of achieving eradication goals by bodies such as the International Task Force for Disease Eradication has identified diseases that could be eradicated. The criteria for this attribution as eradicable, the definitions guiding policy, and examples of programmes and strategies are provided here. This article pleads for scientific, health policy and editorial communities to be more consistent in the use of the terms control, elimination and eradication, and to adhere to published definitions.

Progress in controlling, eliminating or eradicating infectious and non-infectious diseases are a key part of the international health agenda [1]. However, the use of the associated terminology is often loose, misleading or inappropriate. Some programmes have specific public health objectives and target dates determined by one or more resolutions of the World Health Assembly (WHA) and/or regional health committees. These resolutions refer to CONTROL (see Glossary), elimination or ERADICATION of diseases or conditions (Table 1). However, despite the clear definitions available (Glossary), these words are often used interchangeably and inaccurately in the international literature and in the public and animal health arena. Some of these resolutions refer to the elimination as a public health problem of a particular disease. Epidemiological criteria to define the achievement of that goal are often not specified [2] (e.g. WHA resolution 50.29 for the elimination of lymphatic filariasis). Sometimes the criteria are indicated as targets to be achieved at district level (e.g. neonatal tetanus elimination as <1 case per 1000 live births per year) or at national level (e.g. leprosy elimination as <1 case per 10 000 people per year). In other diseases, such as onchocerciasis or Chagas disease, technical committees can endorse monitoring and evaluation criteria, which measure progress toward sustained interruption of transmission [2,3] that is judged to eliminate the public health problem.

Concepts of control, elimination and eradication

In 1988, the International Task Force for Disease Eradication (ITFDE; <http://www.cartercenter.org>) was formed to evaluate systematically the potential for eradication of candidate diseases and to identify specific barriers to eradication. The criteria used to assess the feasibility of eradication are provided in Box 1 [4]. The original ITFDE used these criteria to review >90 diseases, 30 of them in depth, and concluded in 1993 that only six diseases could probably be eradicated using existing technology, namely, dracunculiasis, rubella, poliomyelitis, mumps, lymphatic filariasis and cysticercosis.

The ITFDE has recently been re-established to evaluate the present situation. The Dahlem workshop, which was held in Berlin in 1997 [5], introduced the term EXTINCTION to indicate that an organism no longer existed on the planet. Thus, smallpox, which has been eradicated [6], is not yet extinct because stocks were retained in secure laboratories. Extinction is a concept that refers to the global demise of a species, for example, the dodo or the passenger pigeon. It is possible that, as vertebrate species become extinct through loss of biodiversity, host-specific or host-restricted infectious agents or ectoparasites (many as yet not described) have or will become extinct with their hosts. However, deliberate extinction of an infectious agent has yet to be achieved.

There is evidence that some insect vector species have become extinct as a result of vector control operations. This is the case with *Simulium* cytospecies or cytoforms, in particular, where certain locally restricted and genetically distinct forms have not been found in a specific area after

Glossary

Control: Reduction of disease incidence, prevalence, morbidity or mortality to a locally acceptable level as a result of deliberate efforts. Continued intervention measures are required to maintain the reduction.

Elimination of disease: Reduction to zero of the incidence of a specified disease in a defined geographical area as a result of deliberate efforts. Continued intervention measures are required.

Elimination of infection: Reduction to zero of the incidence of infection caused by a specified agent in a defined geographical area as a result of deliberate efforts. Continued measures to prevent re-establishment of transmission are required.

Eradication: Permanent reduction to zero of the worldwide incidence of infection caused by a specific agent as a result of deliberate efforts. Intervention measures are no longer needed.

Extinction: The specific infectious agent no longer exists in nature or the laboratory.

Table 1. Resolutions pertaining to disease control programmes^a

Disease	Target	Source of target (year target was set)	Target date
Leprosy	Elimination as a public health problem in all countries (i.e. prevalence of < 1 case per 10 000 population in each country).	WHA 44.9 (1991)	2005 (country)
Chagas disease	Interruption of vector and serological (transfusion) transmission in all endemic countries in Latin America.	WHA 51.14 (1998)	2010
Lymphatic filariasis	Elimination as a public health problem and the interruption of transmission ^b	WHA.50.29 EM/RC.47/R.11	2020
Dracunculiasis (guinea worm)	Eradication; country-by-country certification of elimination of transmission; certified by the International Commission.	WHA.44.5 (1991) WHA 57.9	1995 ^c 2009
Measles	Reduction in the number of measles deaths, worldwide, by half.	UNGASSC (2002)	2005
Neonatal tetanus	Elimination as a public health problem (i.e. to arrive at a rate of neonatal tetanus < 1 case per 1000 live births per year, at the district level).	WHA.42 (1989) (revised to 2001 and then to 2005) ^d	2005
Onchocerciasis in the Americas (OEAP)	Elimination as a public health problem, defined as elimination of morbidity in the six countries in the Americas.	PAHO 14.35 (1991)	2007
	Eliminate parasite transmission in those countries or foci where feasible	WHA 47.32 (1994)	No target date
Onchocerciasis in West Africa (OCP)	Elimination of the disease as a public health problem and an obstacle to socio-economic development (defined as maintaining the annual biting rate < 1000 per person per year and annual transmission potential < 100) ^e .	WHA 47.32 (1994)	2002
Onchocerciasis in Africa (APOC)	Elimination of onchocerciasis as a disease of public health and socio-economic importance throughout Africa.	WHA 47.32 (1994)	2007
Trachoma	The elimination of blinding trachoma as blinding disease.	WHA 51.11 (1998)	2020

^aAbbreviations: APOC, African Programme for Onchocerciasis Control (<http://www.worldbank.org/gper/apocpage.htm>); OCP, Onchocerciasis Control Programme in West Africa (<http://www.worldbank.org/gper/ocppage.htm>); OEAP, Onchocerciasis Elimination Programme for the Americas (see: <http://www.cartercenter.com>); PAHO, Pan-American Health Organization (<http://www.phao.org>); UNGASSC, United Nations General Assembly Special Session for Children; WER, Weekly Epidemiological Record (<http://www.who.int/wer/>); WHA, World Health Assembly (<http://w3.who.org/gb/mwha.htm>).

^bCurrent working goal is five-year cumulative incidence of < 1 per 1000 in children, six to ten years old born after the initiation of the mass drug administration, and continued for at least five years.

^cThe target date for eradication was revised in May 2004 to 2009 (see WHA 57.9). It is believed that transmission will continue as long as civil unrest continues in countries such as Sudan.

^dWeekly Epidemiological Record (1999) 74, 73–80 and see publication WHO/V&B/02.09

^eThe number of infective larvae potentially transmitted to one person per year at a given point within a geographical area.

control operations, for example, *Simulium sanctipauli* (Djodi form) and *Simulium soubrense* (Chutes Milo) [7]. Similarly, earlier attempts to control blackflies removed *Simulium damnosum sensu lato* populations from Jinja, Uganda and Kinshasa, Congo. These examples, while they cannot be verified in the absence of cytological identification or knowledge concerning their true specific status, indicate that genuine species could have become extinct as a result of vector control activities [8]. This has implications for any eradication of *Glossina* spp., and the correct terminology in this case should be extinction if a species no longer exists on the planet [9].

Elimination refers to the interruption of transmission of the organism and the reduction-to-zero case incidence from a defined geographical area [5]. The term local eradication has been proposed, but it is inaccurate, given the strict Dahlem definition of eradication, which focuses on the worldwide achievement of the interruption of transmission, and the consequent possibility to stop any disease-specific intervention (see p. 113 of Ref. [10]).

The statements in WHA resolutions (and elsewhere) (Table 1) of the 'Elimination of a disease as a public health problem' further confuse usage, particularly when clear epidemiological criteria for the achievement of this goal are not indicated. Programmes that have such objectives can be considered as intensified control programmes, for which there is evidence that a significant reduction in disease incidence can be achieved within a period of years as a result of an intensified effort. The reduced costs of that

particular disease intervention then become affordable by the local health system. For some diseases, the achievement of the elimination as a public health problem can result in complete interruption of transmission (e.g. in lymphatic filariasis [11] or onchocerciasis [3,8]). However, evidence and knowledge must be consolidated to refine present WHA resolutions with achievable epidemiological criteria or with the indication that sustained elimination of transmission is feasible.

We draw attention here to suggested terminology from consensus meetings or groups which should be accepted and disseminated more widely to avoid inappropriate usage [12]. The Glossary provides agreed definitions from the Dahlem workshop of 1997 [5], which built on the recommendations of the first ITFDE meeting [5,10,12]. The conference 'Global Disease Elimination and Eradication as Public Health Strategies', held 23–25 February 1998 in Atlanta, USA, endorsed these definitions [10]. The more extensive use of the term 'elimination as a public health problem' followed the Onchocerciasis Control Programme (OCP) which has succeeded over a 28-year period in eliminating onchocerciasis as a public health problem and as an impediment to socio-economic development in ten West African countries [3]. In China [11], Japan, Korea, Solomon Islands, Suriname and Trinidad and Tobago [2], elimination of lymphatic filariasis caused by *Wuchereria bancrofti* has been achieved, and transmission of *Brugia malayi* has been interrupted in Sri Lanka (C.H. Gautamadasa, MD

Box 1. Criteria for targeting a disease for eradication

Criteria developed by the International Task Force for Disease Eradication and modified by the Dahlem conference [5,12].

Biological and technical feasibility

Natural history of biological agent
 Non-human reservoir
 Effective intervention tool
 Effective delivery strategy
 Simple and practical diagnostic
 Sensitive surveillance
 Field-proven strategies

Costs and benefits

Cases averted per year
 Coincident benefits
 Intangible benefits
 Estimated annual direct global savings
 Estimated total external financing

Societal and political consideration

Political commitment (endemic and/or industrialized countries)
 Social support (endemic and/or industrialized countries)
 Disease burden in politically unstable areas
 Core partnerships and advocates
 Technical consensus
 Donor base (number of donors of US\$ 1 million or more)

Thesis, University of Colombo, Sri Lanka, 1986). The domiciliary transmission of *Trypanosoma cruzi* by *Triatoma infestans* has been interrupted in five countries in South America through indoor residual insecticide spraying of synthetic pyrethroids [13,14].

There are several examples of what was termed eradication in the history of parasitic or vector-borne disease control [15,16] (Table 2). It is important to distinguish between the ELIMINATION OF INFECTIONS (e.g. measles) and ELIMINATION OF DISEASES (e.g. neonatal tetanus), and the consequences of certain diseases (e.g. blinding trachoma). Impairments due to certain disabling diseases remain or even progress further after the infections have been cured or transmission ceased. This means that there is a need to continue provision of health care to patients suffering the disabling consequences of diseases after the interruption of transmission has been achieved (e.g. Chagas disease, lymphatic filariasis, onchocerciasis, leprosy). This makes the distinction between the agent and its pathology crucial, if epidemiological parameters pertaining to transmission (e.g. annual transmission potential, vector infectivity and incidence) are used as criteria for monitoring and evaluation [2,3,14].

The WHA resolution for dracunculiasis eradication urged WHO to set up and implement a formal certification process, without waiting for the achievement of the interruption of transmission in the last endemic country. Already the International Commission for the Certification of Dracunculiasis Eradication has certified 168 countries free from dracunculiasis transmission. Guinea worm (dracunculiasis) transmission has been certified as having ceased in India, Pakistan, Iran, Senegal and Yemen. Steady progress is being made in Africa, apart from Sudan [17] and three other African countries (Chad, Cameroon, Kenya) where there have not been any recorded cases of guinea worm transmission for periods

varying from five to nine years, and are in pre-certification status [18]. Certification of polio eradication is a specific remit of national, regional and global groups, according to the nature of the disease, its epidemiology and modalities of transmission [19,20]. Although the working modalities of the certification process of these two eradication efforts differ according to the biological characteristics and epidemiology, the need to strengthen the disease-specific surveillance before and after the reporting of zero cases is a common factor. Local surveillance systems can be reinforced by advertising rewards, establishing rumor registers and investigating all rumors [17]. The appointment of independent commissions is done by the WHO Director General, to whom they report.

The high cost of eradication efforts is justified because they are time limited and they offer a permanent solution. By contrast, disease control implies a long-term and indefinite commitment. A control programme should be cost-effective and, if possible, should reduce the target disease to a level at which costs for ongoing control measures are sustainable. Control programmes seek to reduce morbidity and mortality, thereby reducing the public health importance of the target disease. To intensify control measures to the level required to achieve local elimination or complete interruption of transmission requires a significantly increased cost per case treated or prevented, especially towards the end of the programme. Interruption of transmission might not be feasible for technical, financial or ecological reasons, unless more effective interventions are developed.

The inappropriate use of 'regional eradication' in the context of regional successes can further confuse the debate [4,5]. This terminology has sometimes been used for the elimination of polio in the Americas, Europe and western Pacific countries, although WHO has always used the term 'certification of interruption of indigenous transmission of wild polio virus' [19]. A similar situation pertains in measles where the terms elimination, eradication and control are used inconsistently in recent publications [20,21].

The classic eradication programme was the smallpox eradication programme, which achieved its target in 1977 [6]. To date, no parasitic disease has been eradicated, but the eradication of dracunculiasis is moving towards this goal [17,18]. When dracunculiasis eradication is achieved, the term extinction can be validly applied because no laboratory stock or animal reservoir will exist as humans are the only definitive host of this parasite.

Interruption of transmission in limited areas (previously referred to as local eradication) has been achieved in several situations. Table 2 summarizes a selection of these.

A feature of these examples is that they refer to islands, isolated or geographically limited populations, or areas where the parasite is at the edge of its geographic range. Clearly, the advantages of isolation and a greater ability to control animal or human population movements are important.

The malaria eradication programme established by WHO in 1955 was abandoned following the development of DDT and chloroquine resistance, while eradication of

Table 2. Examples of local elimination of transmission, disease or possible vector extinction^a

Disease and target organism (common name or form)	Geographical site	Year	Methodology	Refs
Sleeping sickness <i>Glossina palpalis</i> (tsetse); <i>Trypanosoma brucei gambiense</i>	Principe	1905–1916	Sticky back-pack trapping	[25]
Cattle trypanosomiasis <i>Glossina austeni</i>	Zanzibar	1996	Sterile insect release	[9]
Malaria <i>Anopheles gambiae</i>	Northeast Brazil; Ceara State, Egypt	1930s–1940	Larviciding; identification and/or deconstruction of breeding sites	[15,16]
Onchocerciasis <i>Simulium damnosum sensu lato</i>	Nile, Jinja, Uganda	1973	DDT application to breeding site	[8]
<i>Simulium sanctipauli</i> (Djodji form)	Benin, Ghana	1988	Larvicide application to breeding sites	[27]
<i>Simulium soubrense</i> (Chutes Milo form)	Guinea	1989	Larvicide application (Temephos, Bti)	[27]
<i>Simulium neavei</i>	Kenya, Uganda	1950–1950	DDT applied as larvicide	[26,27]
<i>Simulium damnosum</i>	Congo, Kinshasa	1949–1952	DDT applied as larvicide	[28]
Brugian filariasis <i>Brugia malayi</i>	Sri Lanka	1960–1970	DEC treatment; environmental control of pond vegetation (larval sites); larvicides	[9]; ^b
Hydatid disease <i>Echinococcus granulosus</i>	Iceland New Zealand	1860–1960s 1960s	Destruction of stray dogs; control of abattoirs; control of offal use; treatment of dogs with cesticides.	[29,30]
Dracunculiasis <i>Dracunculiasis medinensis</i> (guinea worm)	India, Pakistan, Iran	1970 to date	Provision of clean water; water filtration; Temephos in ponds to kill <i>Cyclops</i> ; case containment; village-based surveillance; active surveillance; regular reporting; pre-certification activities.	[17,18]
Lymphatic filariasis <i>Wuchereria bancrofti</i>	Solomon Islands	1970s	Indoor DDT house spraying (<i>Anopheles punctulatus</i>); DEC selective treatment	[11,31,32]
	Suriname	1950s–1970s	DEC selective treatment and/or DEC salt, and environmental control of <i>Culex</i> .	
	China	1950s →		
<i>Cochliomyia hominivorax</i> (screw worm)	Southeastern USA, Mexico Libya	1960–1970 1980s	Sterile insect release	[24]

^aAbbreviations: Bti, *Bacillus thuringiensis israeliensis*; DEC, diethyl carbamazine citrate.

^bC.H. Gautamadasa, MD Thesis, University of Colombo, Sri Lanka, 1986.

malaria in sub-Saharan Africa was an insurmountable challenge. However, successful programmes in Brazil and Egypt eliminated *Anopheles gambiae* [15,16], and DDT spraying or environmental management eliminated malaria from southern Europe, North Africa and parts of the Middle East [22]. It should be pointed out that the experience of eliminating *An. gambiae* from Brazil and Egypt continues to be referred to as eradication, even in some of the most recent publications [15].

A further complication is the loose use of eradication for diseases that are clearly not eradicable [e.g. neonatal tetanus, African trypanosomatids (both animal and human trypanosomatids have extensive wildlife reservoir hosts) and rinderpest]. Rinderpest (a *Morbillivirus*) infects a large number of different wild game species (African buffalo, eland, kudu, wildebeest, various antelopes and wild suids) in Africa [23]. A study of Food and Agricultural Organization websites (<http://www.fao.org>) found that the words eradicate, eliminate and control are used

interchangeably in two pages. The World Organization for Animal Health (OIE) website (http://www.oie.int/eng/maladies/fiches/a_A040.htm) states that rinderpest has been eradicated from several countries and sub-regions despite the existence of multiple reservoir hosts. The New World screw worm, *Cochliomyia hominivorax*, found in large parts of the Americas and eliminated from Libya in 1990 (following an introduction from South America), has been described as eradicated, whereas elimination is a more appropriate term (see, for example, <http://www.moa.gov.jm/projects/NWSWP.htm>) [24]. Eradication has also been used to describe the removal of the tsetse, *Glossina austeni*, from Zanzibar, where again elimination is the term that should be used, given the distribution of this species on the East African mainland [9].

Concluding comments

We suggest that scientists should recognize and accept the terminology of the Dahlem workshop [5]. It is also

inappropriate, confusing and misleading to have different health communities (for humans and animals) involved with infectious agents and insect vectors, applying clearly defined terms so loosely and inaccurately. Editors should also assume responsibility for maintaining terminological precision.

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Lymphatic filariasis and *Brugia timori*: prospects for elimination

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***Brugia timori* is a pathogenic filarial nematode of humans, replacing the closely related species *Brugia malayi* on some islands in eastern Indonesia. Recent studies on Alor island show that, locally, *B. timori* is still of great public health importance, causing mainly acute filarial fever and chronic lymphedema. PCR-based**

assays to detect parasite DNA, in addition to assays for detecting specific antibodies that have been originally developed for *B. malayi*, can be used efficiently as diagnostic tools for *B. timori*. In the framework of the Global Program to Eliminate Lymphatic Filariasis, a single annual dose of diethylcarbamazine, in combination with albendazole, was found to reduce the prevalence and density of microfilaraemia persistently. Therefore, elimination of *B. timori* appears to be achievable.

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