Vaccins anti-toxines

tétanus, diphtérie, *C. difficile*, …

O. Epaulard

Infectiologie, CHU de Grenoble

Journées inter-DES sur la vaccination, 11 juin 2026

De la variole

De la rage

D'où vient-on ?

Des toxines bactériennes

De la tuberculose

De la variole

Vaccins vivants atténués viraux

De la rage

Vaccins inactivés

D'où vient-on ?

Des toxines bactériennes

Vaccins subunitaires

De la tuberculose

Vaccin vivant atténué bactérien

D’où vient-on ?

De la variole

Vaccins vivants atténués viraux

Fièvre jaune

Chikungunya

Dengue

Polioméylite

Rougeole

Varicelle

Vecteurs viraux

Vaccins ARNm

De la rage

Vaccins inactivés

Encéphalite japonaise

Coqueluche cellulaire

Hépatite A

Poliomyélite

Des toxines bactériennes

Vaccins subunitaires

Tétanos

Diphtérie

Hépatite B

Pneumocoque

Méningocoque

H. influenzae

Grippe

HPV

C. difficile

De la tuberculose

Vaccin vivant atténué bactérien

Tuberculose

3me ANNÉE. JUIN 1889. N° 6

Les pasteuriens découvrent l'importance des toxines bactériennes …

ANNALES

DE

L'INSTITUT PASTEUR

CONTRIBUTION A L'ÉTUDE DE LA DIPHTÉRIE

(2e MÉMOIRE),

Par E. ROUX et A. YERSIN.

Kitasato et Behring

L’école allemande montre que l’injection de ces toxines déclenche des anticorps chez l’animal, dont on peut se servir en thérapeutique

Sonderabdruck aus der
„Deutschen Medicinischen Wochenschrift" 1890, No. 49.
Redacteur: Sanitätsrath Dr. **S. Guttmann.**

Aus dem hygienischen Institut des Herrn Geheimrath Koch in Berlin.

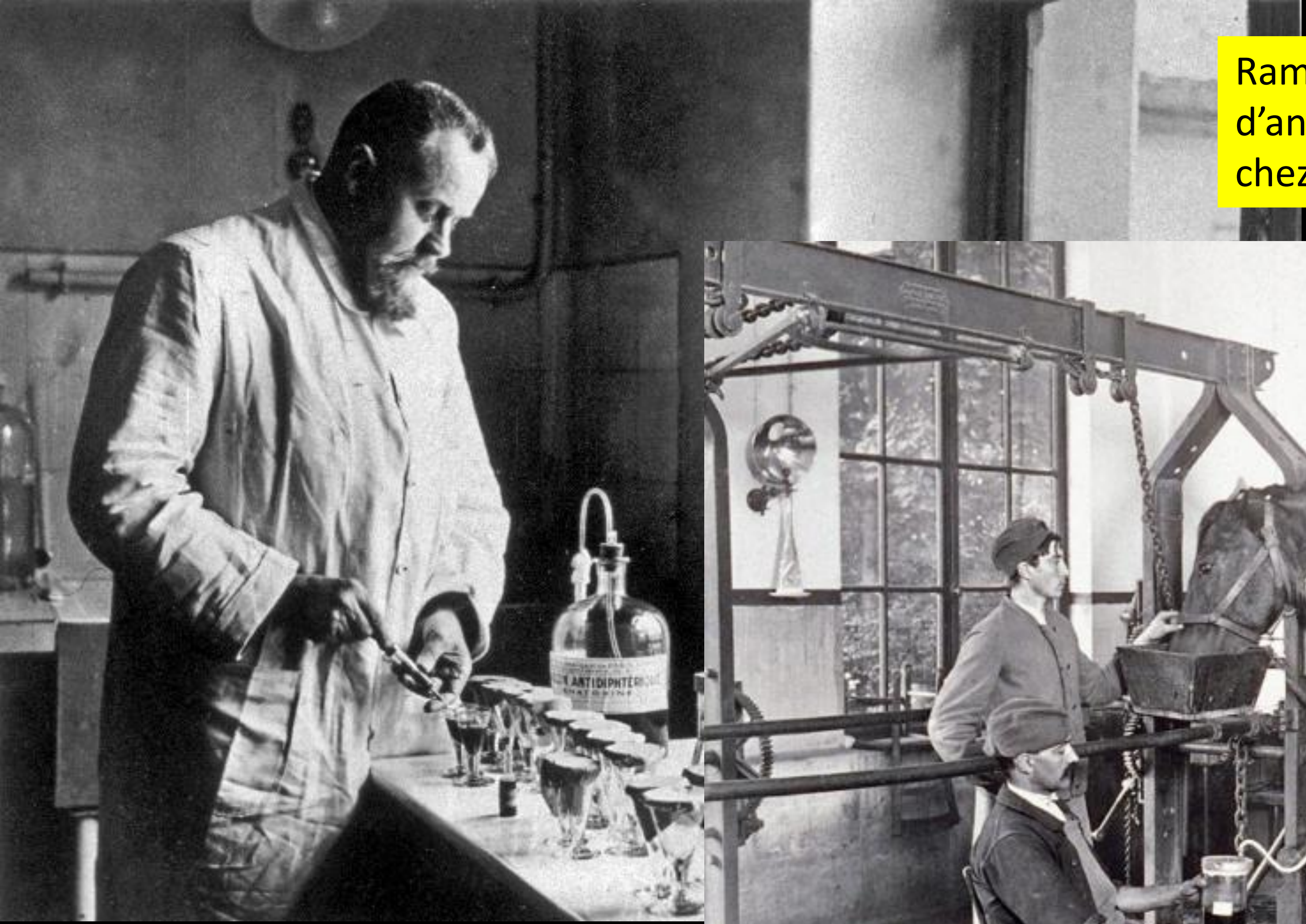
Ueber das Zustandekommen der Diphtherie-Immunität und der Tetanus-Immunität bei Thieren.

Von

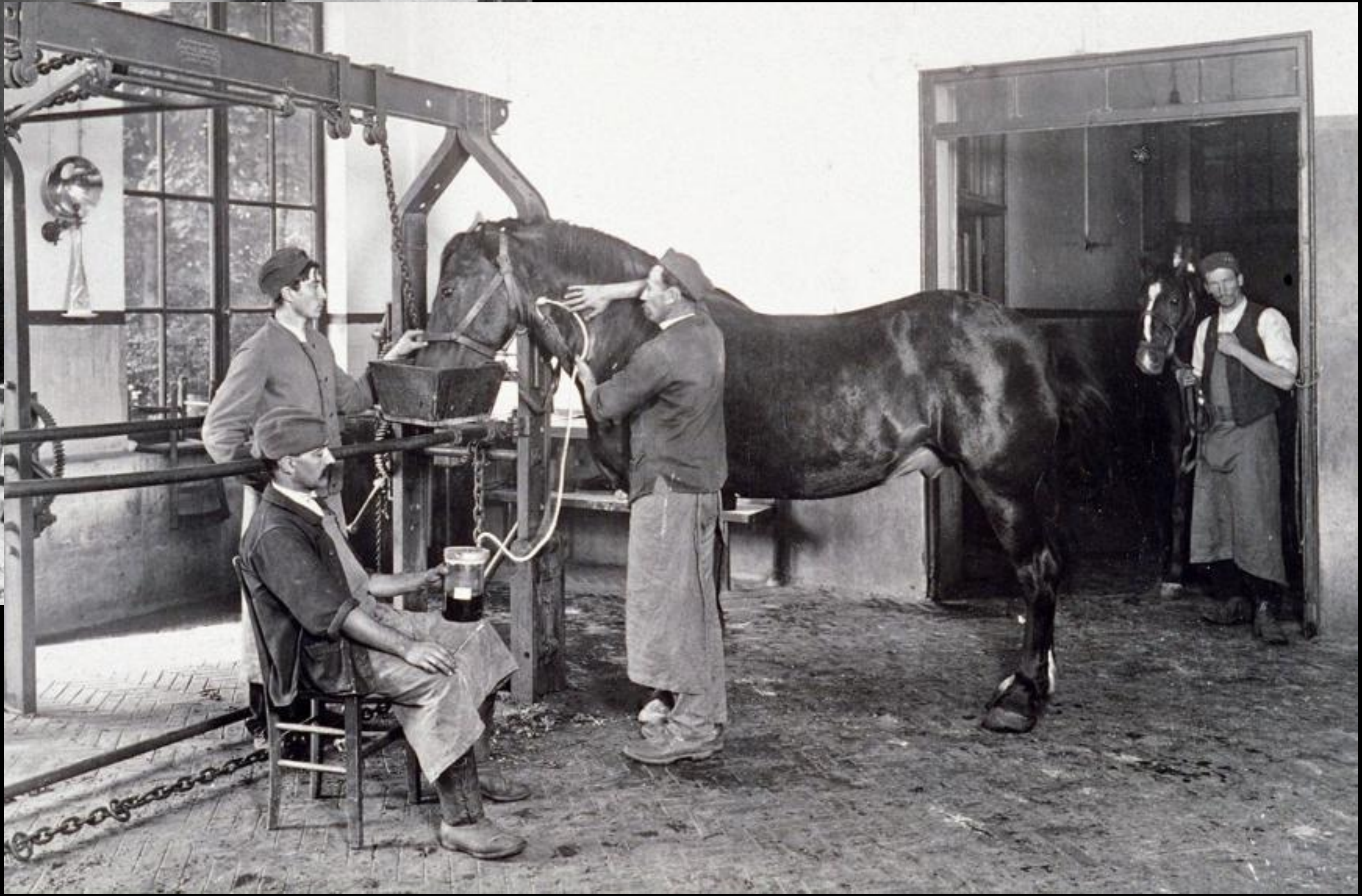
Stabsarzt Dr. **Behring**, Assistenten am Institut, und Dr. **Kitasato** aus Tokio.

Behring sera représenté en boutiquier de sérum …

Ramon en France étudie comment l’injection d’anatoxine peut améliorer la production d’anticorps chez le cheval



Gaston Ramon (1886-1963)




Et c'est Glenny qui découvrira l'effet de quelques milligrammes de dérivés d'aluminium

ORIGINAL

PREPARATION OF ALUM-PRECIPITATED TOXOID FOR USE AS AN IMMUNISING AGENT

M. BARR, M.SC. LOND., A.I.C.

C. G. POPE, D.SC. BRIST.

A. T. GLENNY, B.SC. LOND.

F. V. LINGGOOD, B.SC., PH.D. LOND., A.R.C.S.

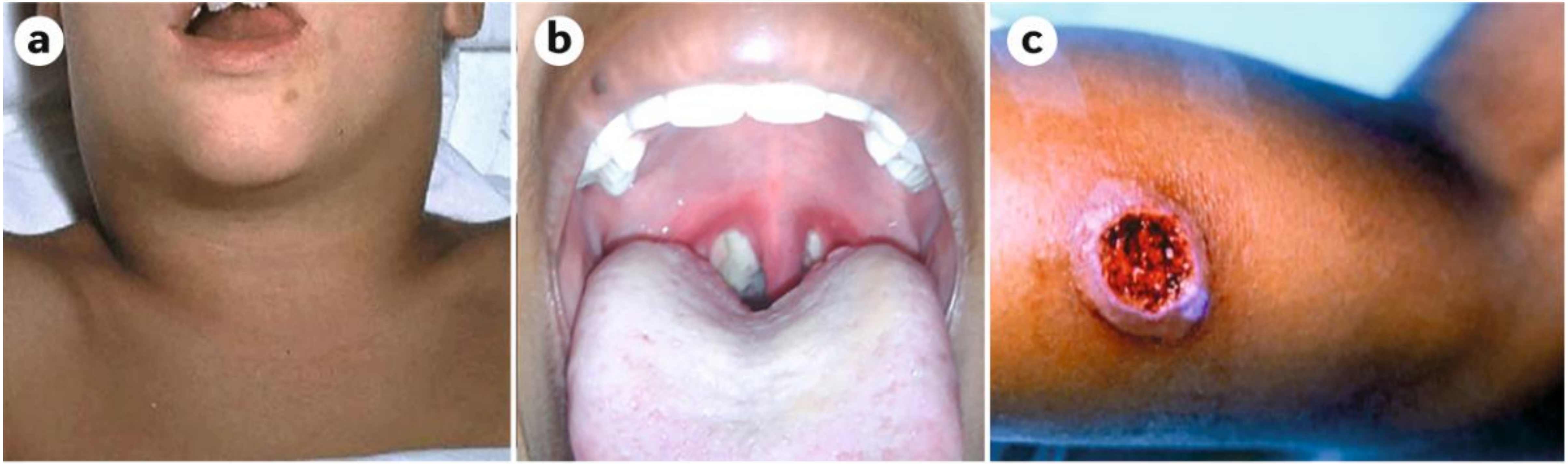
(Wellcome Physiological Research Laboratories)

Toxoid = anatoxine : une forme altérée*, inactive, d'une toxine
(*particulièrement, à l'époque, par le formaldéhyde)

Diphtérie

Diphtheria

*Naresh Chand Sharma[1], Androulla Efstratiou[2], Igor Mokrousov[3], Ankur Mutreja[4], Bhabatosh Das[5] and Thandavarayan Ramamurthy[5]**



Diphtheritic Polyneuropathy

Clinical Analysis of Severe Forms

Michael A. Piradov, MD, PhD, DMSc; Victor N. Pirogov, MD; Lubov M. Popova, MD; Irina A. Avdunina, MD

Table 1. Cranial Nerve Disturbances in 32 Patients With Diphtheritic Polyneuropathy

Cranial Nerves	Duration of Involvement, wk	Frequency*
IX and X	7-8	32 (100)
VII	7-8	28 (88)
III, IV, and VI	5-7	27 (84)
XI	7-9	27 (84)
XII	7-8	23 (72)
V	6-7	17 (53)

*Data are given as number (percentage) of patients.

JCRMHS
Case Report

Diphtheria Myocarditis: A Case Report of a 12 years old girl in Garowe – Somali

Journal of Clinical Case Reports, Medical Images and Health Sciences
Volume 9 Issue 4, 2025
Article Information

Ibrahim Yusuf Hassan[1,2*], Dafa Alla Banga Mahdi[2]

[1]Department of Pediatrics, Yashfiin Women and Children's Hospital, Garowe City Puntland, Somalia.
[2]Department of Cardiology, Faculty of Medicine and Health science, University of Bosaso, Garowe , Somalia.

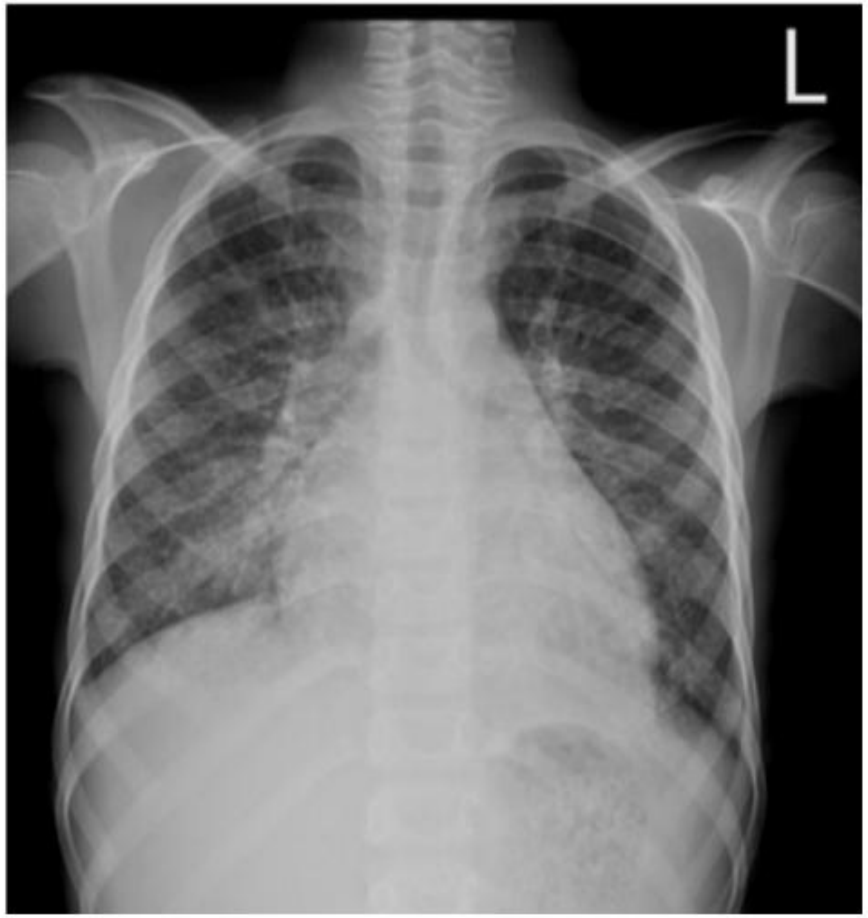
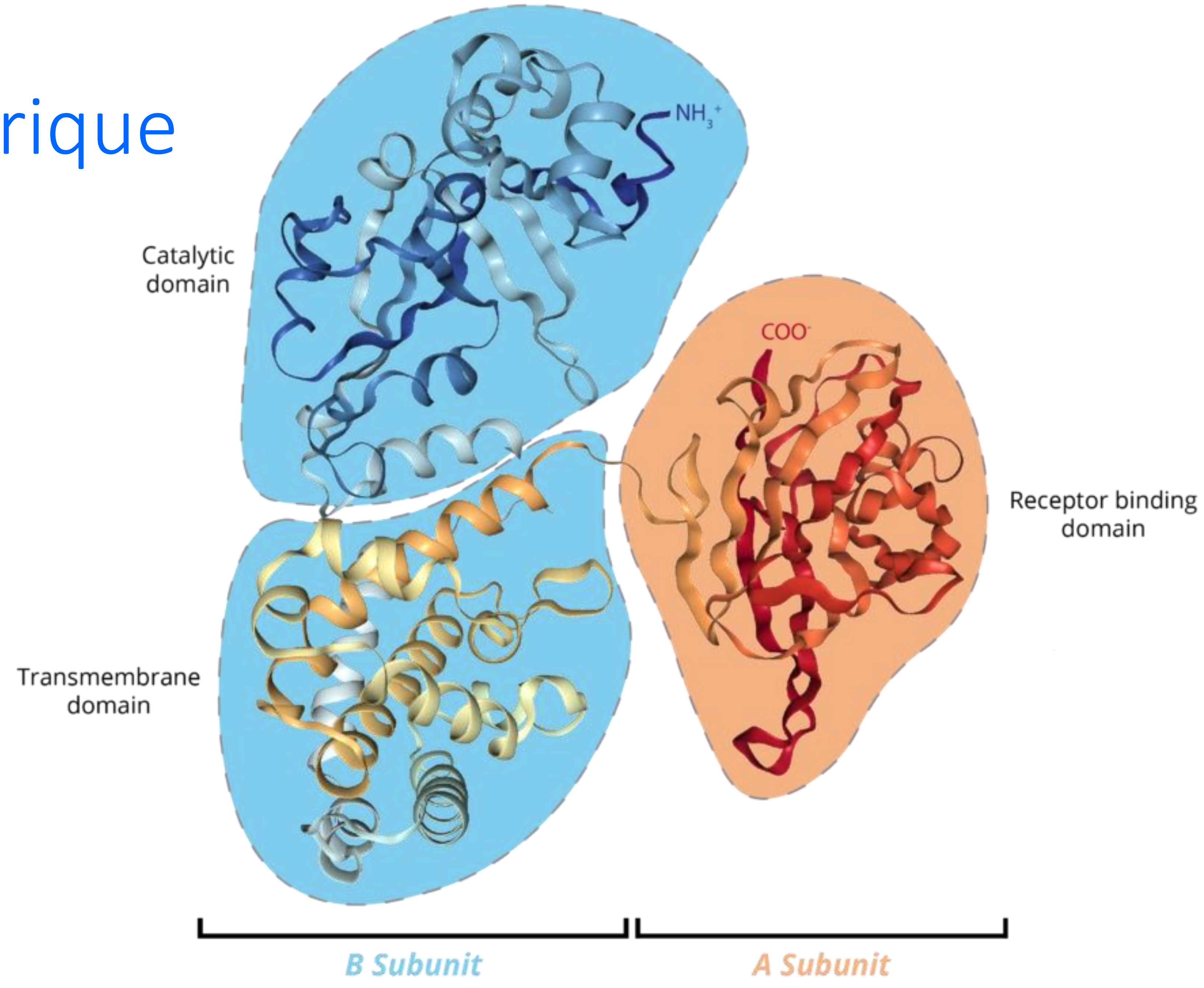


Figure 2: *Chest x-ray of the 12yrs old girl with diotheria myocarditis showing bilateral upper lung vascular diversion and reticulatons which suppestive of grade II pulmonry edema .*

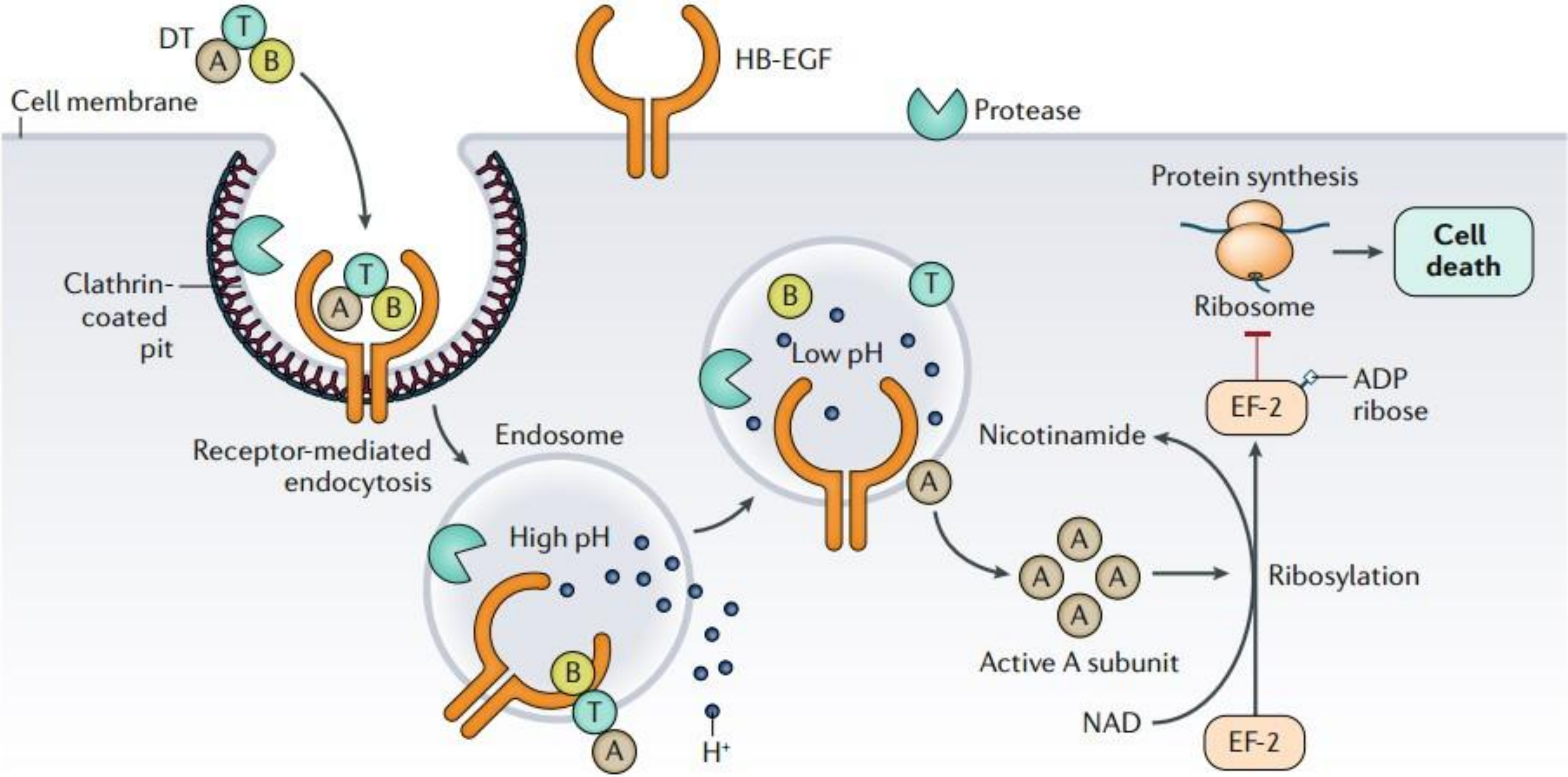
Toxine diphtérique



Diphtheria

Naresh Chand Sharma[1], Androulla Efstratiou[2], Igor Mokrousov[3], Ankur Mutreja[4], Bhabatosh Das[5] and Thandavarayan Ramamurthy[5]*

Heparin-binding epidermal growth factor



Cette étude a précisé quelles altérations tridimensionnelles (et immunogéniques) induisait le formaldéhyde, qui transforme la toxine en anatoxine

Journal of Pharmaceutical Sciences 109 (2020) 543-557

Contents lists available at ScienceDirect

Journal of Pharmaceutical Sciences

journal homepage: www.jpharmsci.org

Pharmaceutical Biotechnology

Identification of Formaldehyde-Induced Modifications in Diphtheria Toxin

Bernard Metz [1,2,*], Thomas Michiels [1], Joost Uittenbogaard [1], Maarten Danial [1], Wichard Tilstra [1], Hugo D. Meiring [1], Wim E. Hennink [2], Daan J.A. Crommelin [2], Gideon F.A. Kersten [1,3], Wim Jiskoot [2,3]

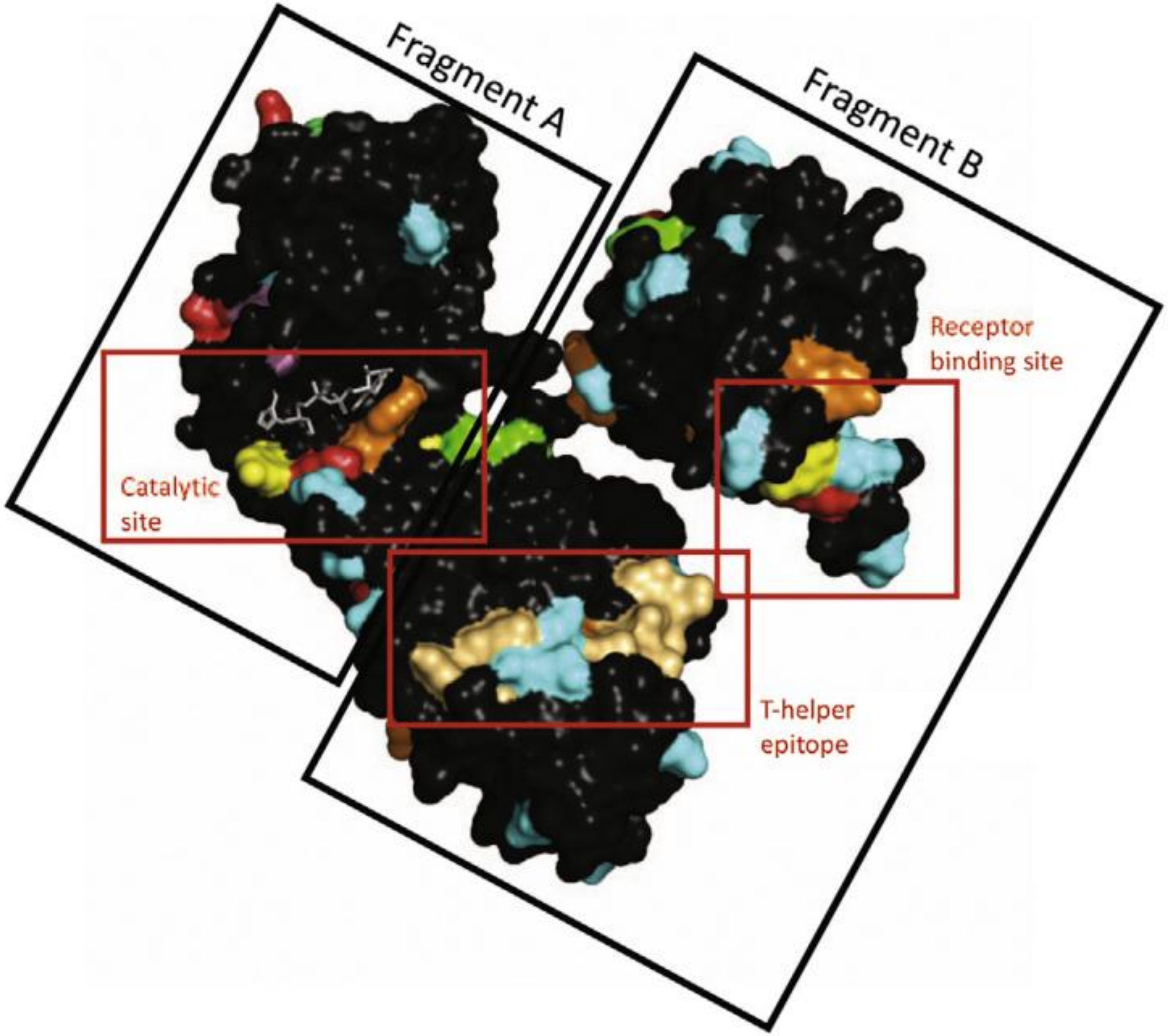
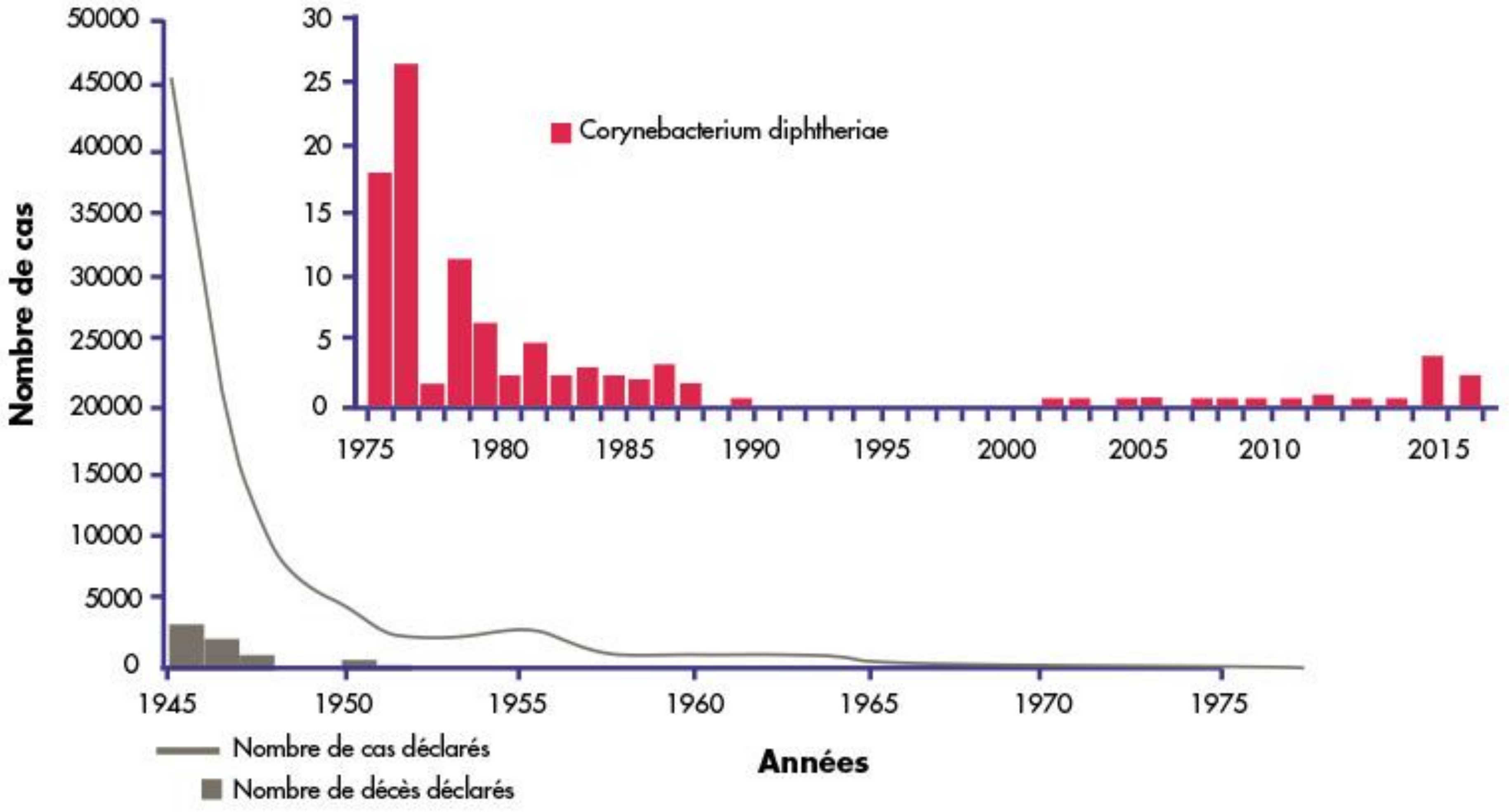


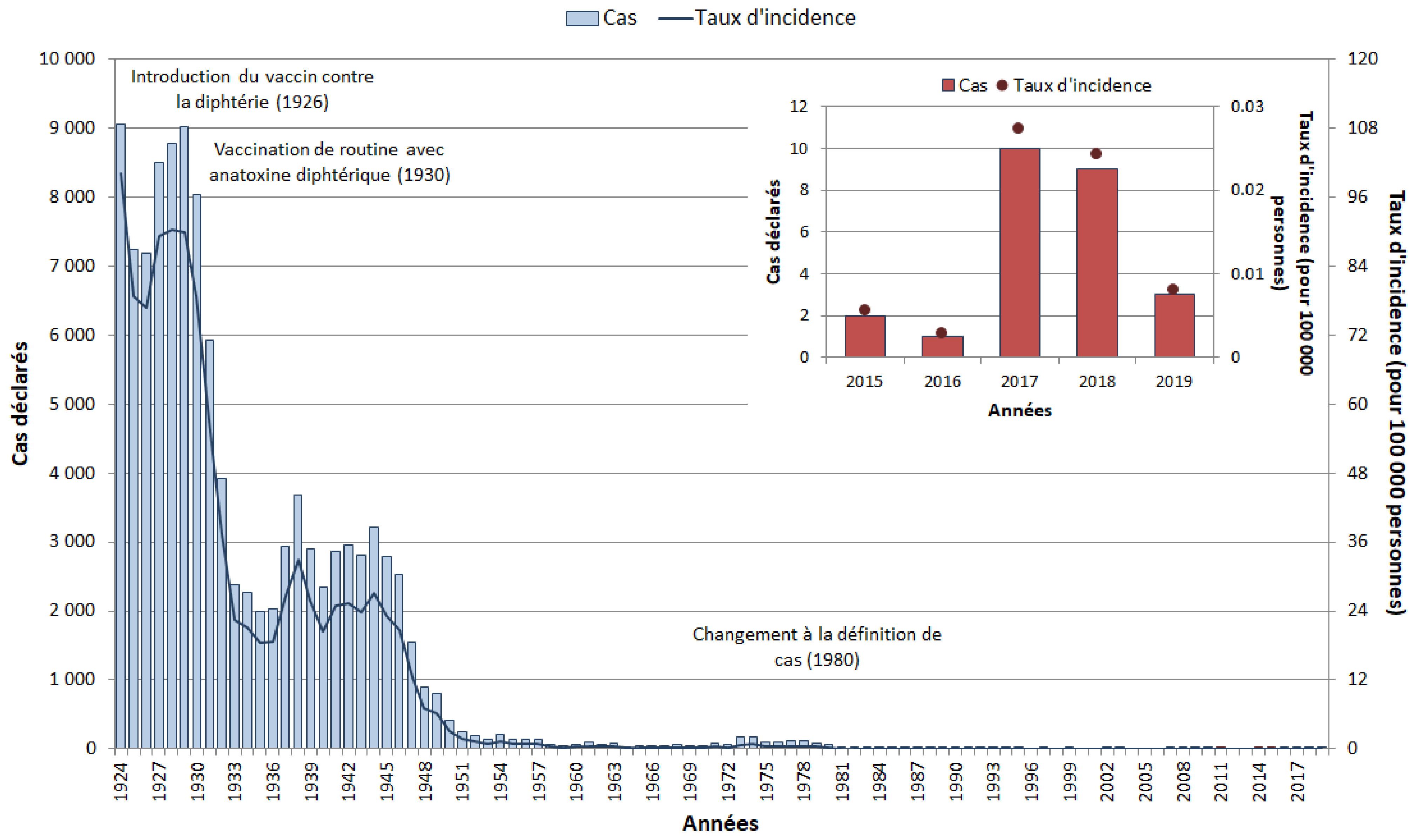
Figure 10. Illustration of formaldehyde/glycine-induced modifications on diphtheria toxin (PDB 1TOX). Amino acid residues that have cross-links being confirmed by mass

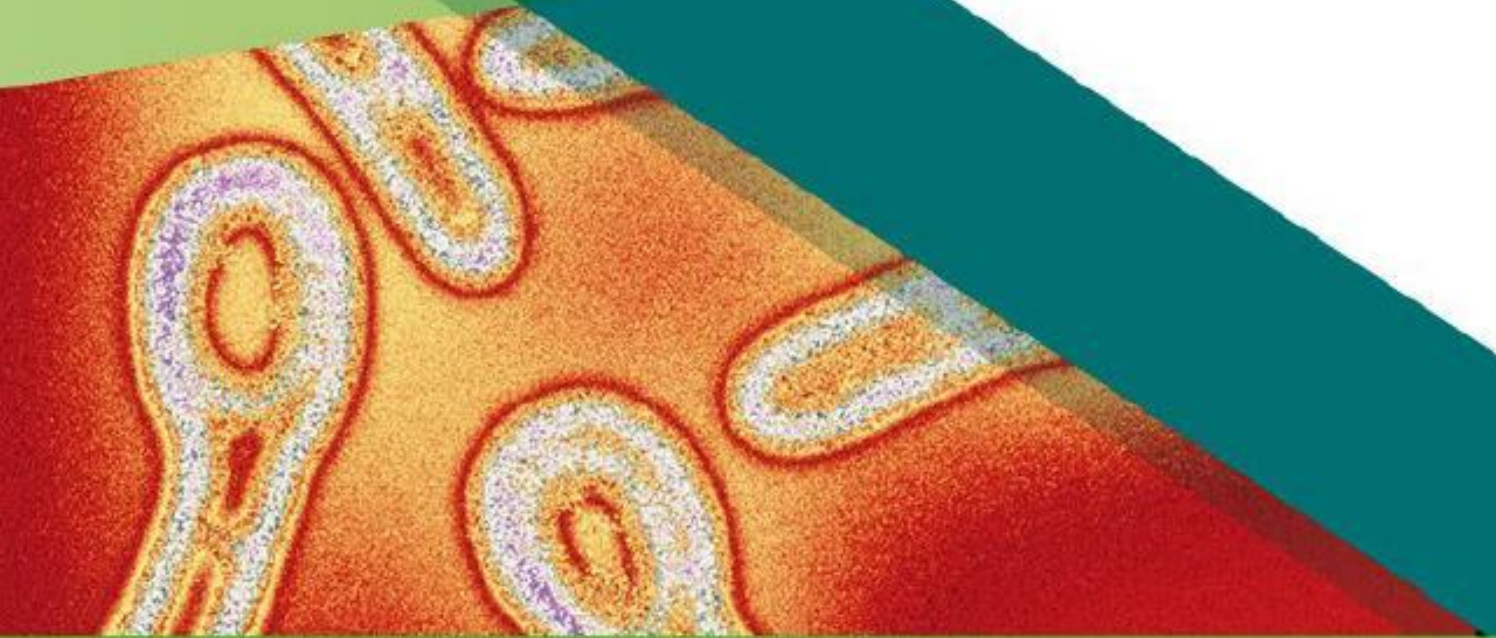
Diphtérie en France, 1945-2015



Sources : Déclarations obligatoires, Santé publique France, Causes médicales de décès, Insem, CépiDc

Diphtérie au Canada





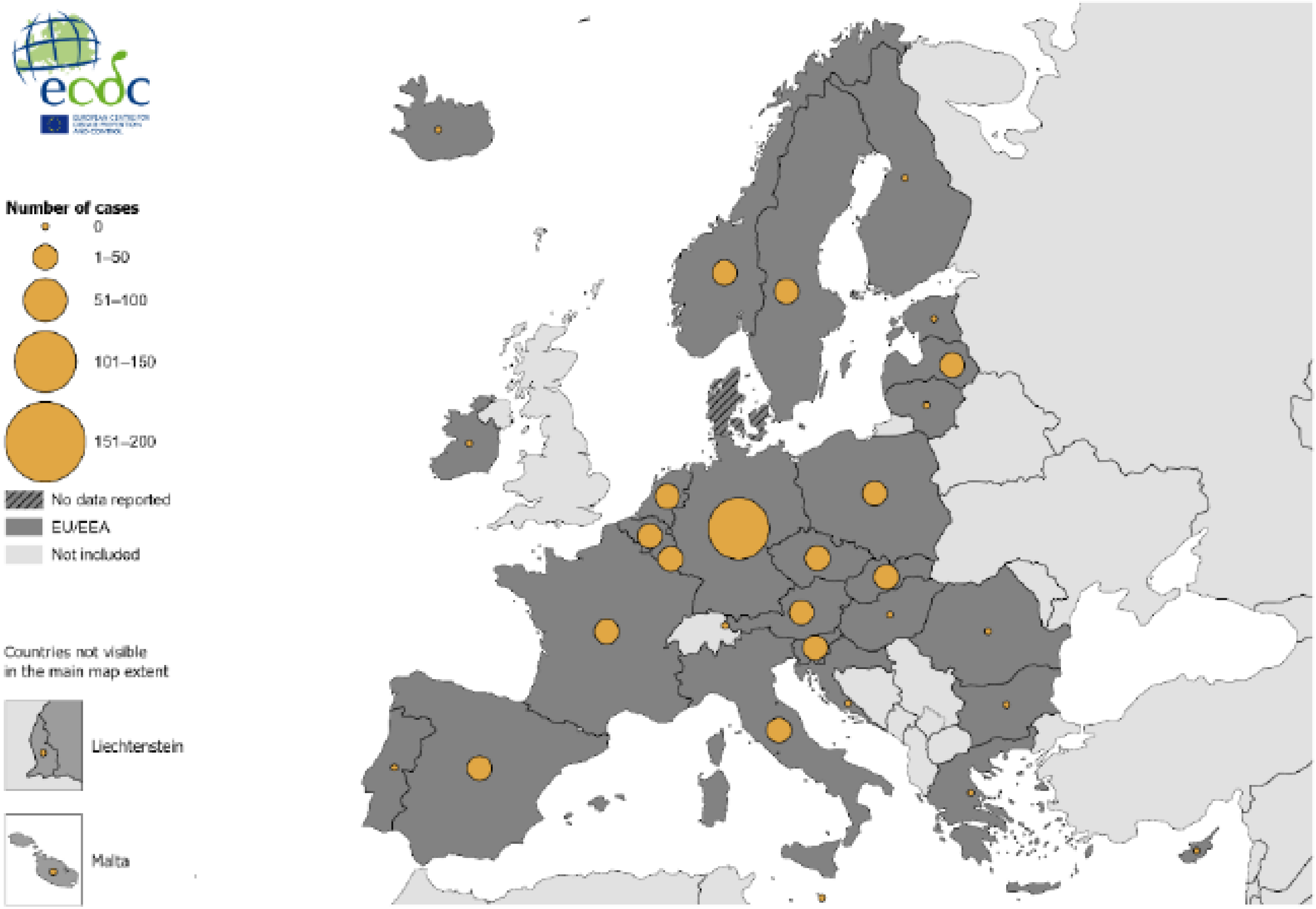
EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL

SURVEILLANCE REPORT

Diphtheria

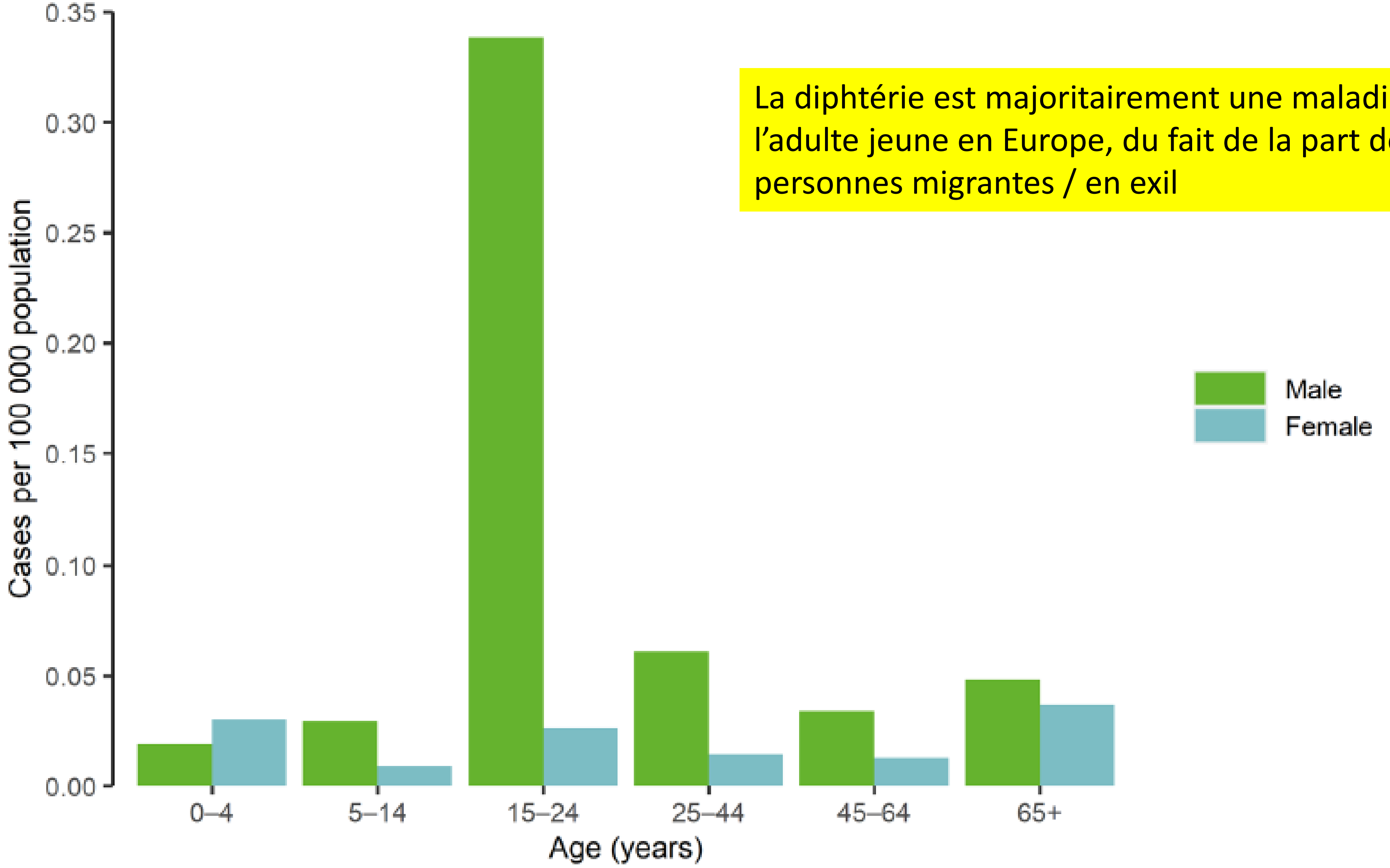
Annual Epidemiological Report for 2023

Figure 1. Diphtheria cases by country, EU/EEA, 2023



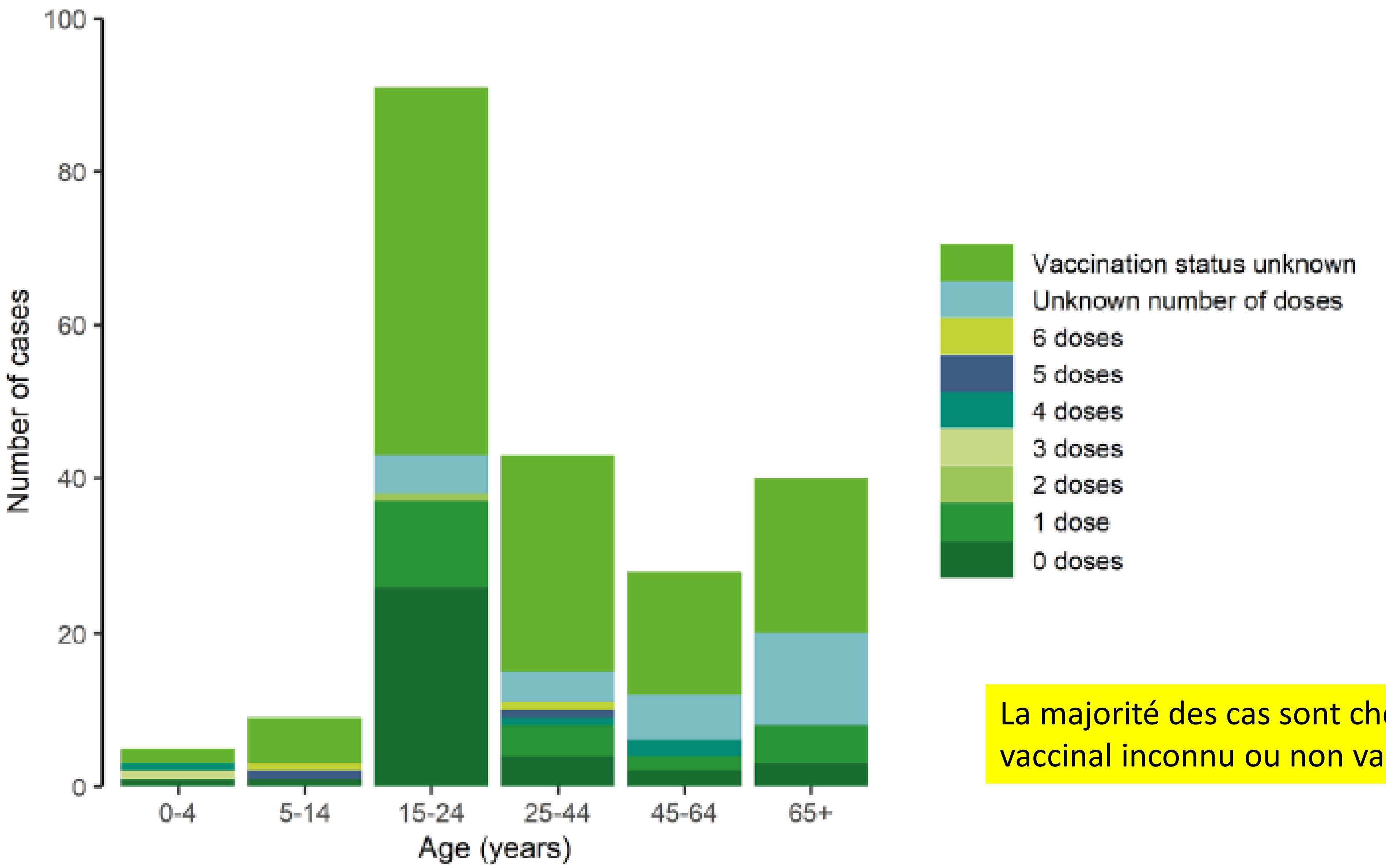
Administrative boundaries: © EuroGeographics. The boundaries and names shown on this map do not imply official endorsement or acceptance by the European Union. Map produced by ECDC on 14 March 2025

Figure 2. Diphtheria cases per 100 000 population, by age and gender, EU/EEA, 2023



La diphtérie est majoritairement une maladie de l’adulte jeune en Europe, du fait de la part des personnes migrantes / en exil

Figure 6. Number of cases of diphtheria by vaccination status and age group, EU/EEA countries, 2023



La majorité des cas sont chez des personnes de statut vaccinal inconnu ou non vaccinées

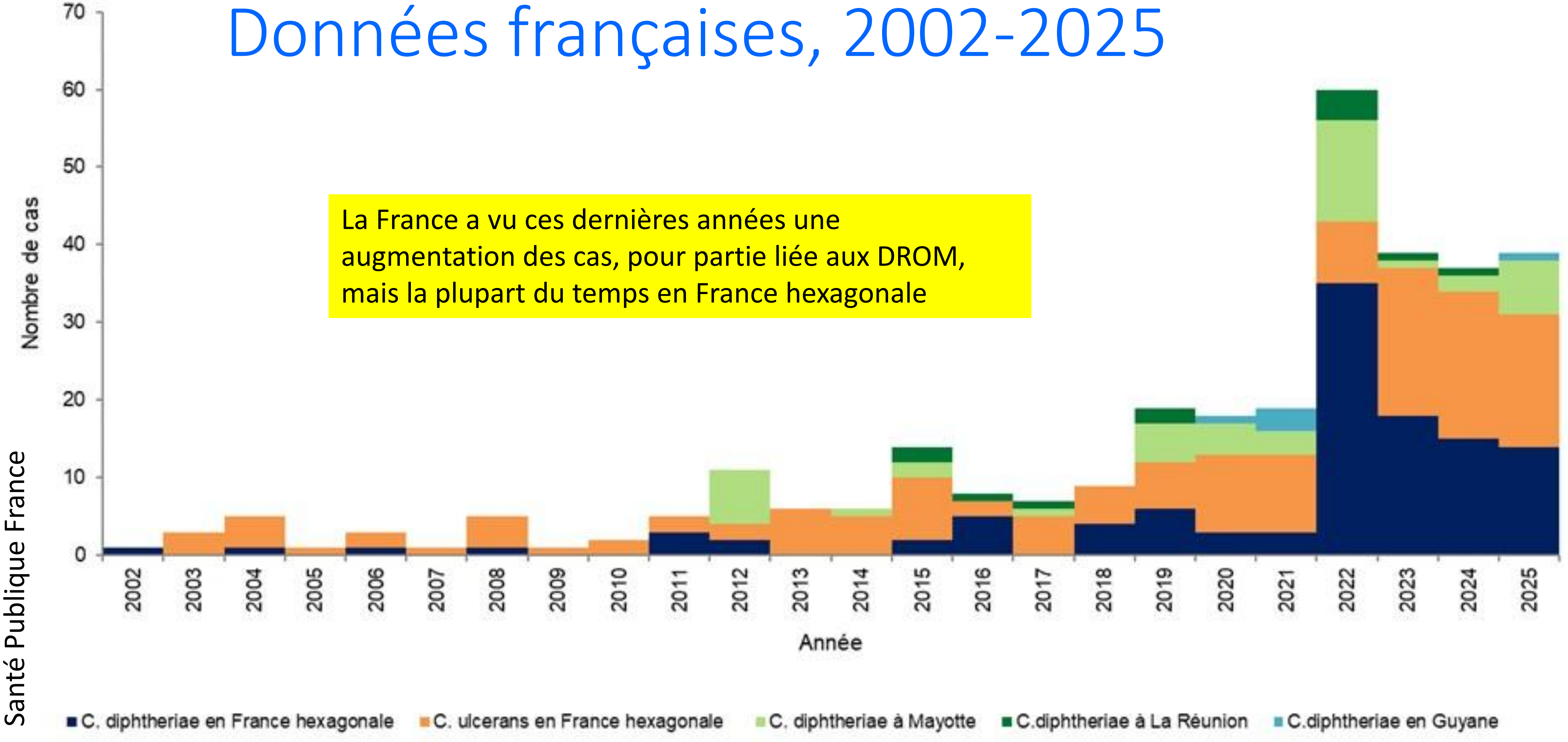
Importation status

Importation status was available for 210 cases, and of these 71 cases (34%) were reported as imported cases. An imported case is defined as a case having been outside the country of notification during the incubation period of the reported disease, and no links to local transmission has been identified. Sixty-nine of the imported cases were caused by *C. diphtheriae*, and two imported cases were due to *C. ulcerans*. Fifty-four (78%) of the imported cases caused by *C. diphtheriae* presented with cutaneous disease, while one case (1.5%) presented with respiratory and cutaneous infection and clinical presentation was unknown for 14 cases (20%). Of the two imported cases caused by *C. ulcerans*, one case presented with cutaneous presentation and clinical presentation was unknown for one case.

The probable country of origin was known for 48 cases (68%) caused by *C. diphtheriae*. They were imported from Afghanistan (25), Syria (11), Philippines (2) Türkiye (2), Eritrea (1), Ethiopia (1), Indonesia (1), Iraq (1), Pakistan (1), Sudan (1), Slovenia (1) and Thailand (1). The two imported cases caused by *C. ulcerans* were imported from Croatia (1) and Sudan (1).

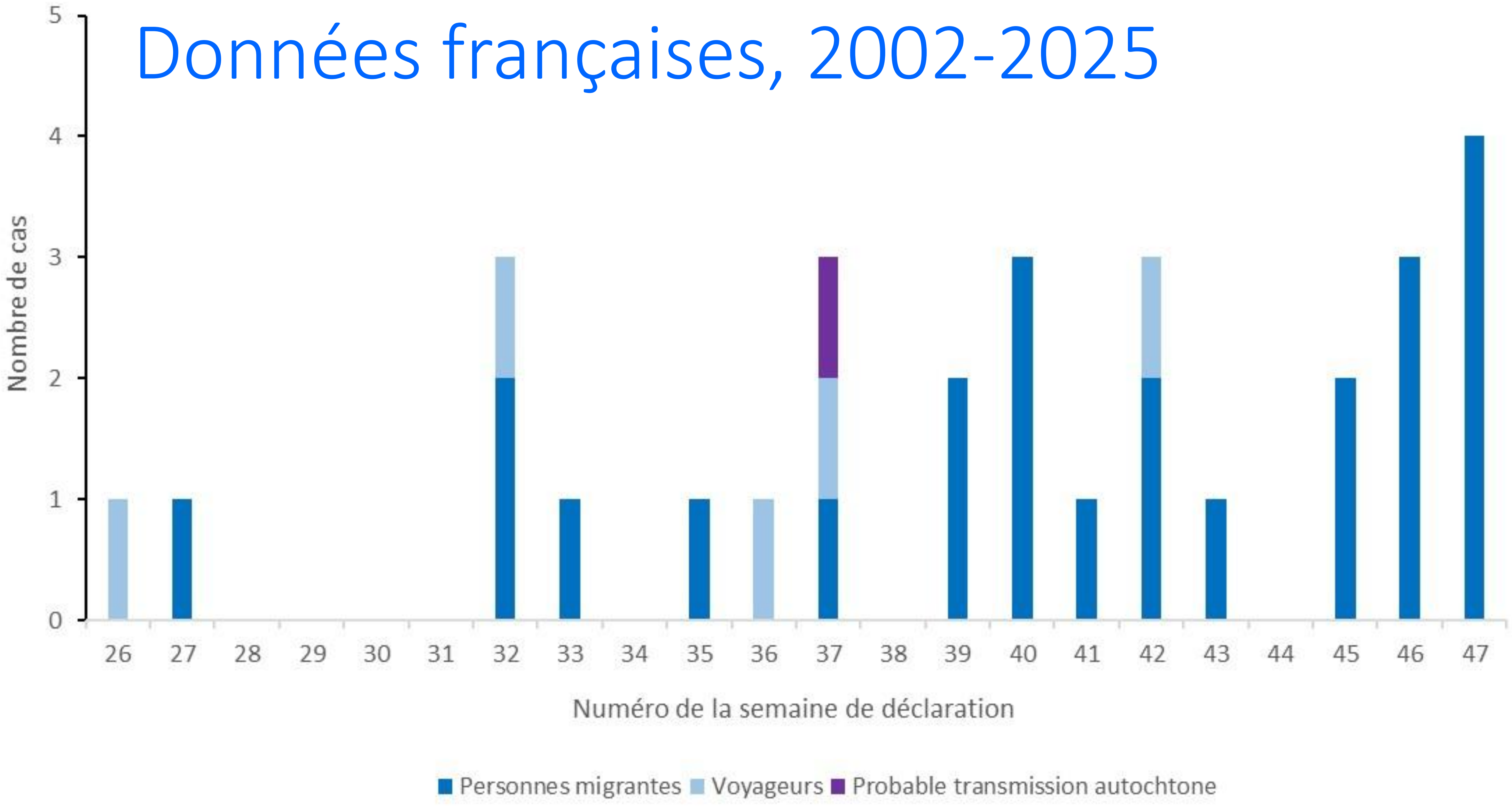
Données françaises, 2002-2025

La France a vu ces dernières années une augmentation des cas, pour partie liée aux DROM, mais la plupart du temps en France hexagonale



Santé Publique France

Données françaises, 2002-2025



Santé Publique France

Diphtheria in the Former Soviet Union: Reemergence of a Pandemic Disease

Charles R. Vitek and Melinda Wharton
Centers for Disease Control and Prevention, Atlanta, Georgia, USA

Plusieurs pays de l'ex-URSS ont vu une augmentation des cas de diphtérie dans les années 1990 – avec des différences marquées entre les classes d'âge

In the years 1990–1997, 150,000 cases of diphtheria were reported in Russia, with more than 3,000 fatalities

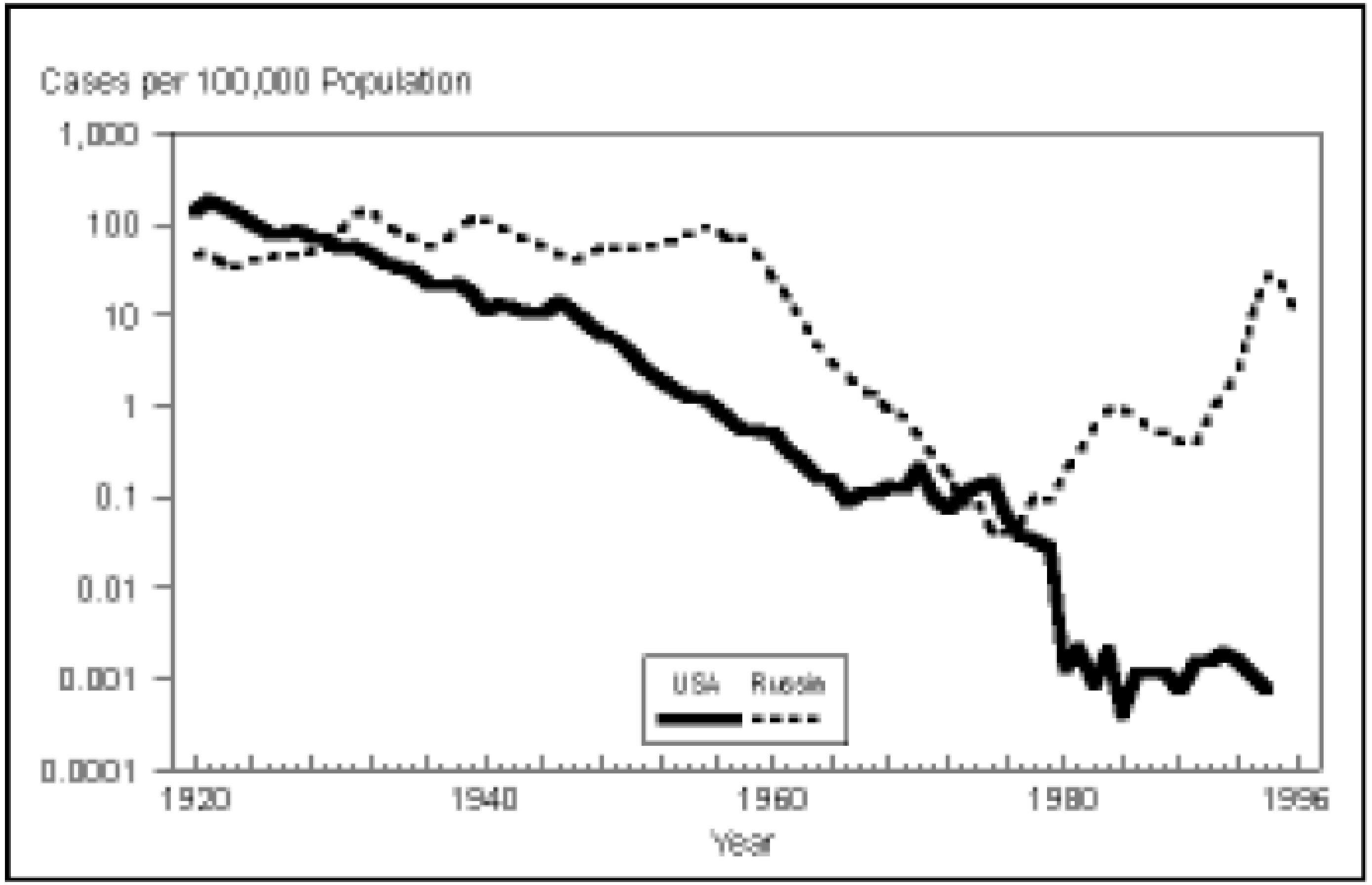


Figure 2. Diphtheria Incidence—United States and Russian Federation, 1920–1996.

Resurgence of diphtheria

Artur M. Galazka[1], Susan E. Robertson[1] & George P. Oblapenko[2]

European Journal of Epidemiology **11**: 95–105, 1995.

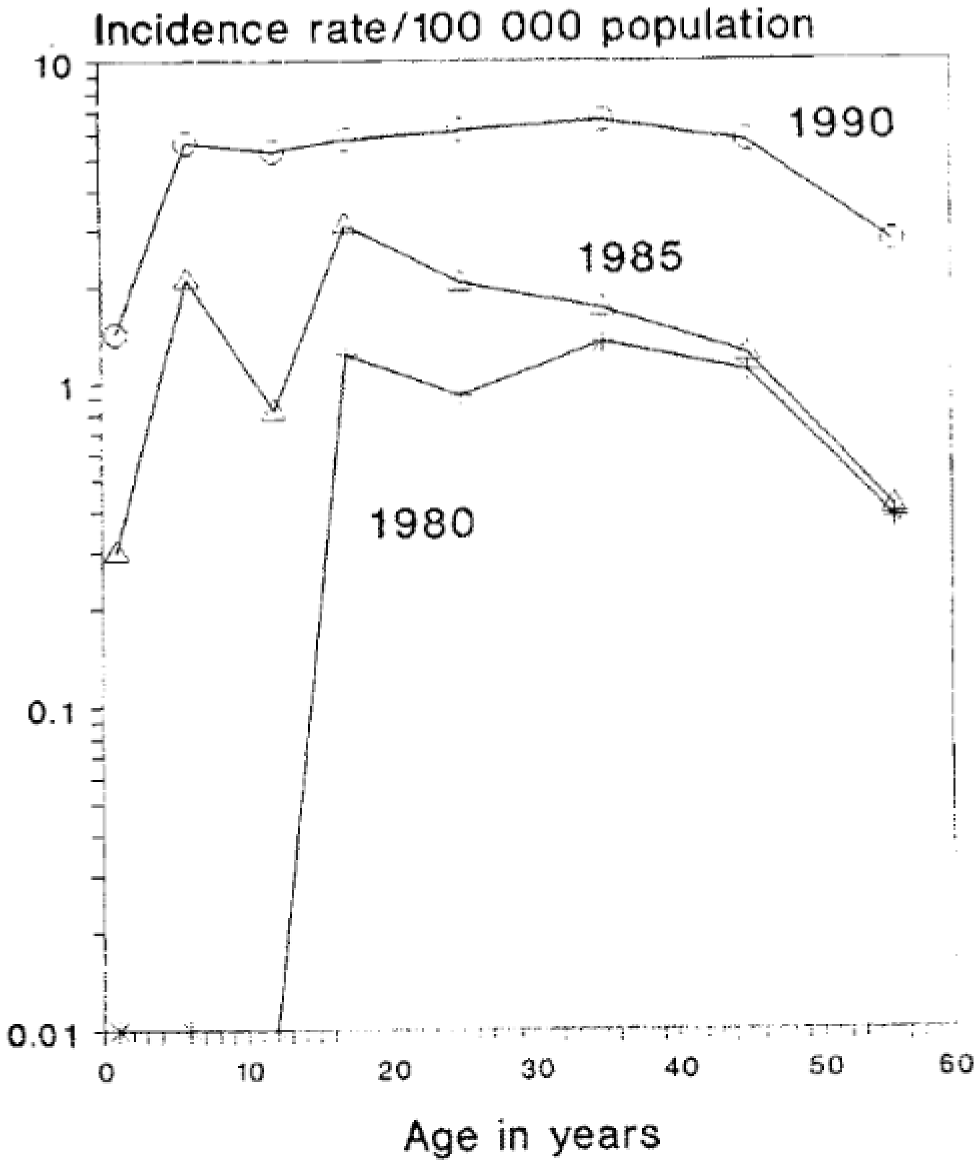


Figure 3. Diphtheria incidence rate per 100,000 population, by age group, Moscow, 1980, 1985, and 1990. Reported by Ministry of Health, USSR.

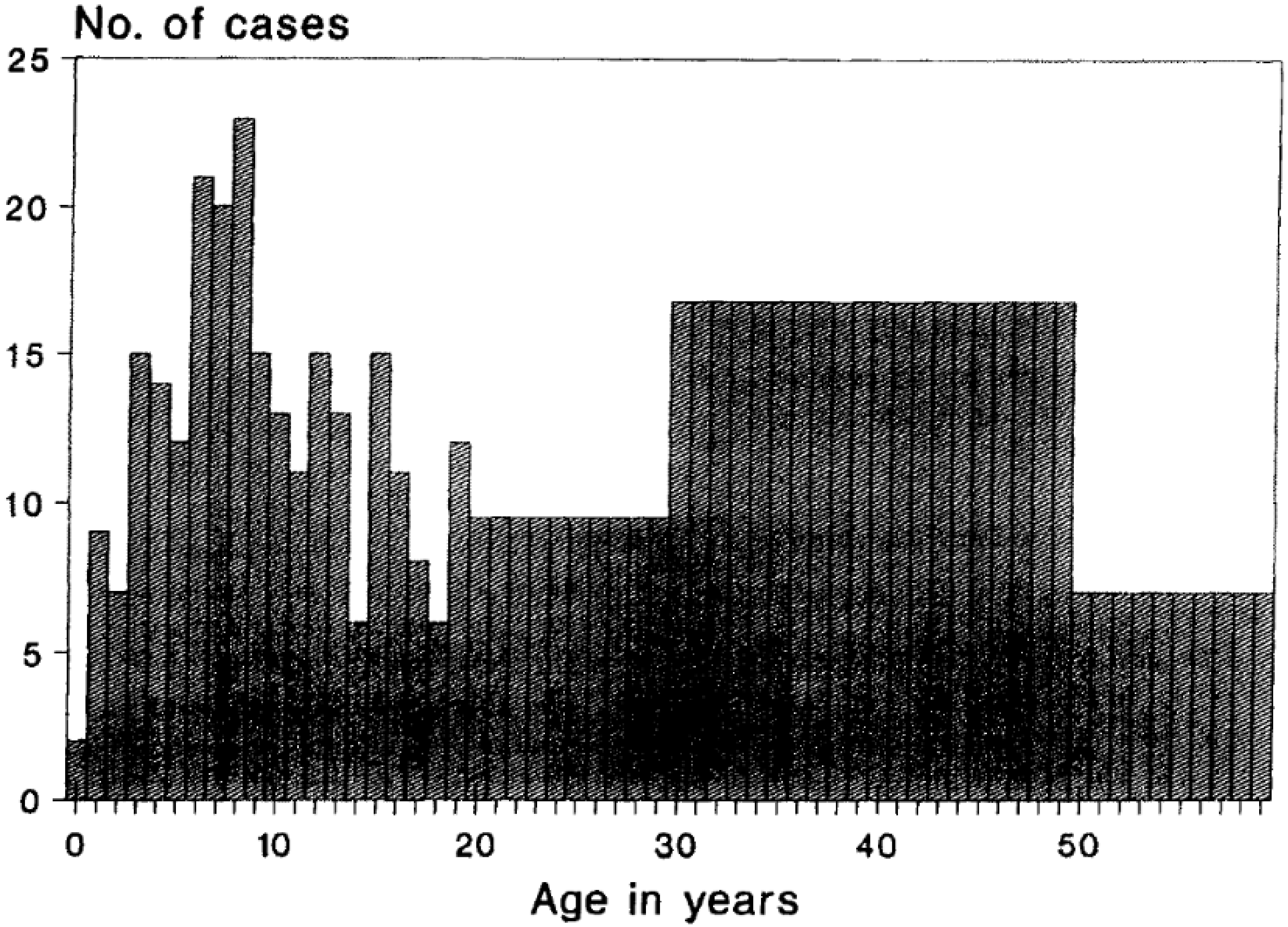


Figure 4. Number of diphtheria cases, by age group, Moscow, 1992 (according to reference 13).

Les âges les plus touchés étaient les enfants et les adultes de moins de 50 ans

Diphtheria in the Russian Federation in the 1990s

Svetlana S. Markina,[1] Nina M. Maksimova,[1] Charles R. Vitek,[3] Erika Y. Bogatyreva,[1,a] and Anatoly A. Monisov[2]

[1]*Diphtheria Epidemiology Branch, Gabrichevsky Institute of Microbiology and Epidemiology, and* [2]*Sanitary-Epidemiologic Surveillance Division, Ministry of Health, Moscow, Russian Federation;* [3]*National Immunization Program, Centers for Disease Control and Prevention, Atlanta, Georgia*

Table 1. Cumulative incidence of, mortality from, and case fatality ratio for diphtheria, by age group, Russian Federation, 1990–1997.

Age group, years	Population in 1994 (to nearest thousand)	No. of cases, 1990–1997	Cumulative incidence[a] (per 100,000)	No. of fatalities, 1990–1997	Cumulative mortality[a] (per 100,000)	Case fatality ratio
<1	1,480,000	431	29.1	33	2.2	7.7
1–2	3,555,000	2280	64.1	156	4.4	6.8
3–6	9,121,000	10,673	117.0	342	3.8	3.2
7–14	18,555,000	18,601	100.2	228	1.2	1.2
15–17	6,320,000	7057	111.7	41	0.7	0.6
18–19	4,213,000	3935	93.4	25	0.6	0.6
20–29	19,703,000	13,366	67.8	72	0.4	0.5
30–39	25,245,000	16,658	66.0	295	1.2	1.8
40–49	18,144,000	18,136	100.0	1172	6.5	6.5
50–59	17,038,000	6577	38.6	460	2.7	7.0
≥60	24,771,000	2242	9.1	143	0.6	6.4
Total	148,146,000	99,861	67.4[b]	2967	2.0	3.0

Russie, 1990

- **Adultes > 60 ans** : immunité contre la diphtérie acquise lors d’infections contractées pendant l’enfance, avant la généralisation de la vaccination ;

- **Adultes nés dans les années 1940 et 1950** : sensibilité à la diphtérie :
  - Pas de vaccination au cours des premières années des programmes de vaccination
  - pas d’immunité naturelle, car la circulation des souches toxigènes avait diminué après la mise en place des programmes de vaccination ;
  - Ces personnes étaient totalement vulnérables à la diphtérie ; elles représentaient la plupart des cas graves et des décès.

- **Jeunes adultes** :
  - vaccinés dans leur enfance mais pas de rappel pour renforcer l'immunité ;
  - Ces adultes étaient sensibles à la diphtérie mais conservaient une certaine mémoire immunologique vis-à-vis de la toxine diphtérique ; les cas graves et les décès étaient rares dans ce groupe.

Post COVID 19 resurgence of diphtheria in Kano, Nigeria: analysis of 18,320 cases

Muhammad Adamu Abbas,[a,e] *Abubakar Labaran Yusuf,*[b,d] *Hassan Adam Murtala,*[c] *Aisha Adam Abdullahi,*[c] *Adam Muhammad Murtala,*[c] *Jordi Bertran Torrelles,*[f] *Muktar Hassan Aliyu,*[g] *and Hamisu Mohammed Salihu*[c,*]

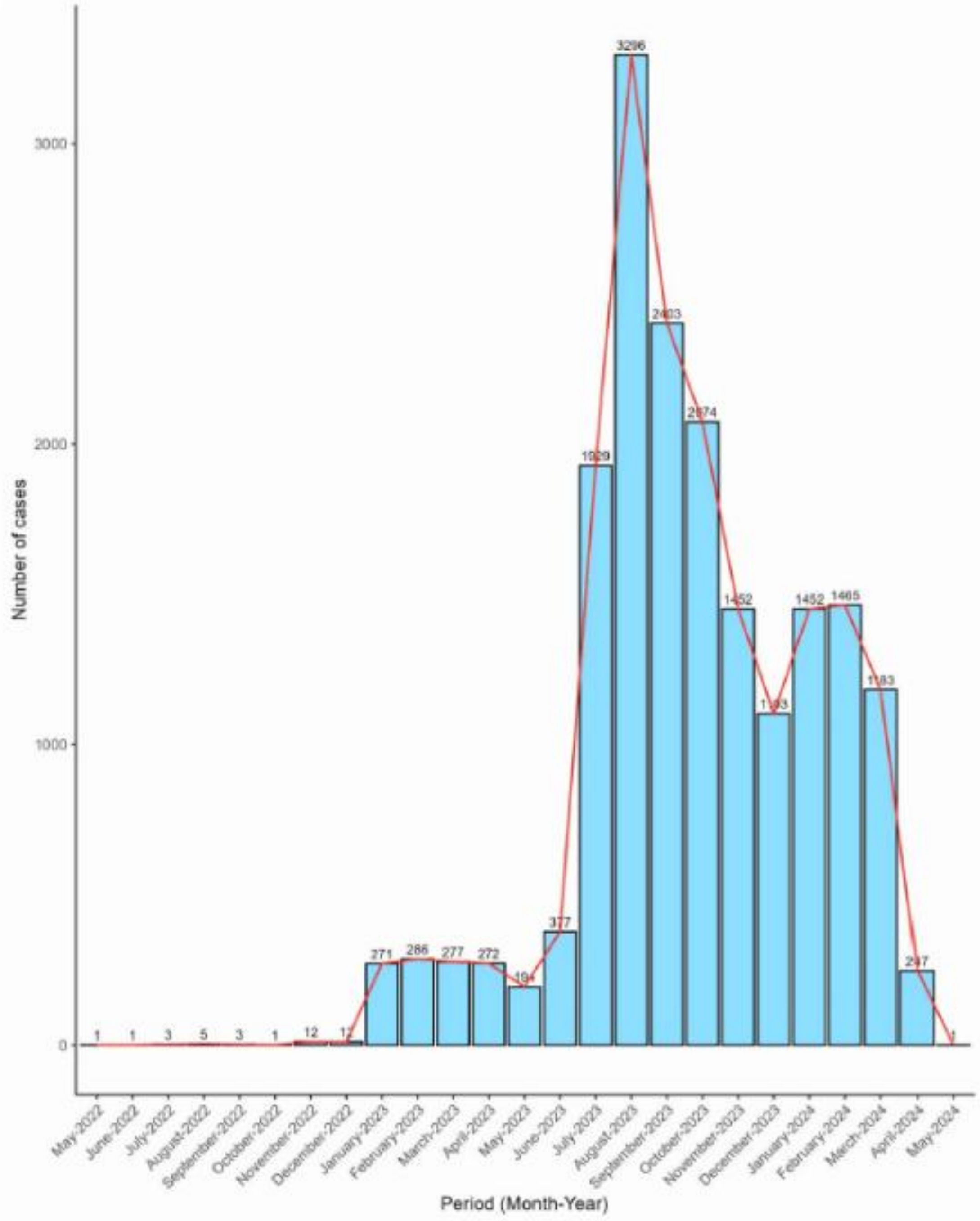


Fig. 2: Diphtheria Epidemic Curve in Kano, Nigeria, February 2022 to April 2024. The bars represent the absolute number of diphtheria

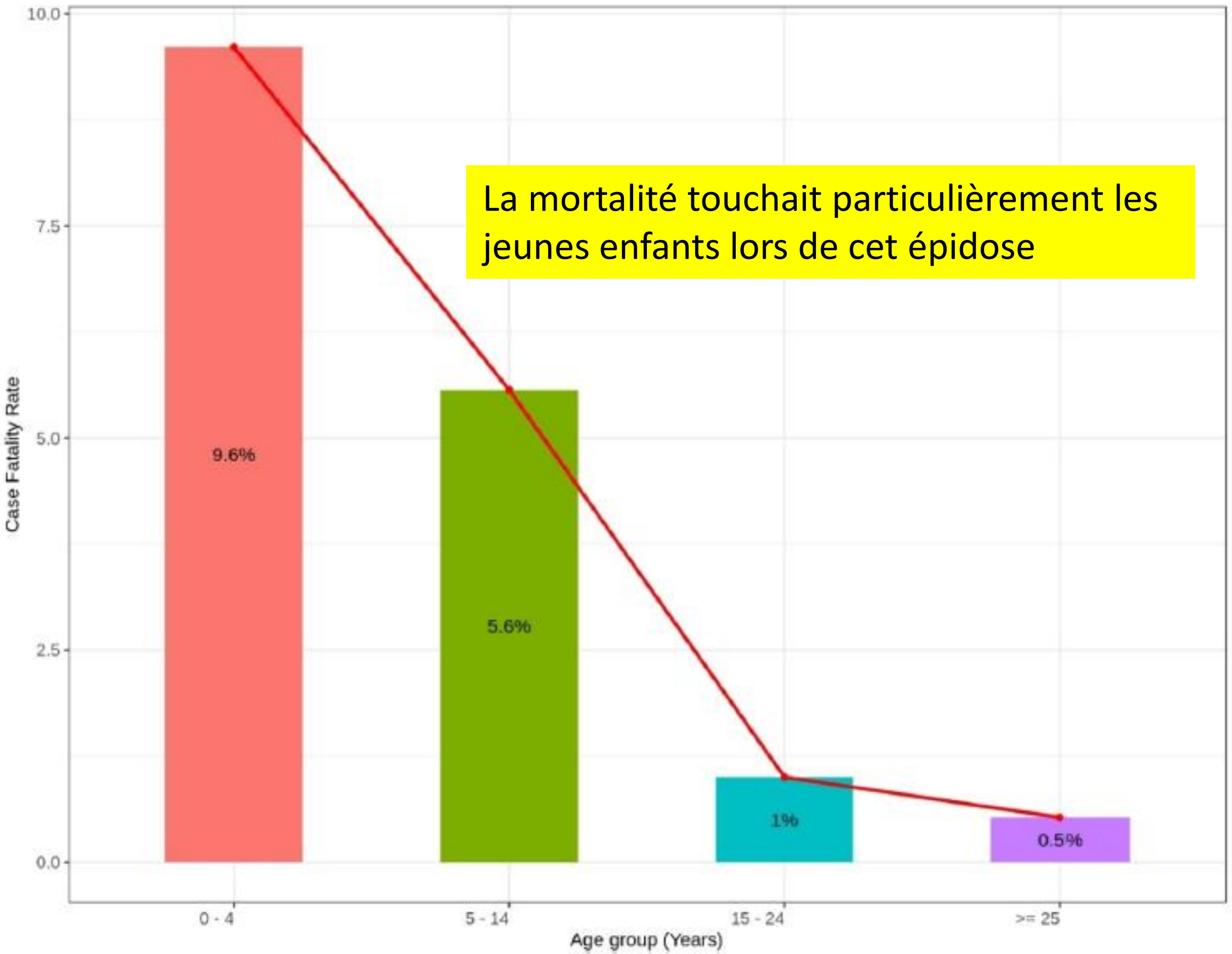


Fig. 4: **Case Fatality Rate (CFR) of Diphtheria by Age Group (in Years).** Barplot illustrates the CFR for diphtheria across four age groups: 0–4 years, 5–14 years, 15–24 years, and ≥25 years. Sample size: *n* = 18,320 cases; 828 deaths. Biological replicates: 1. Statistical test: p = 0.039 (Binomial regression model assessing linear trend in CFR across ordinal age groups). Data source: Kano State Centre for Disease Control surveillance database.


Clinical Infectious Diseases

MAJOR ARTICLE

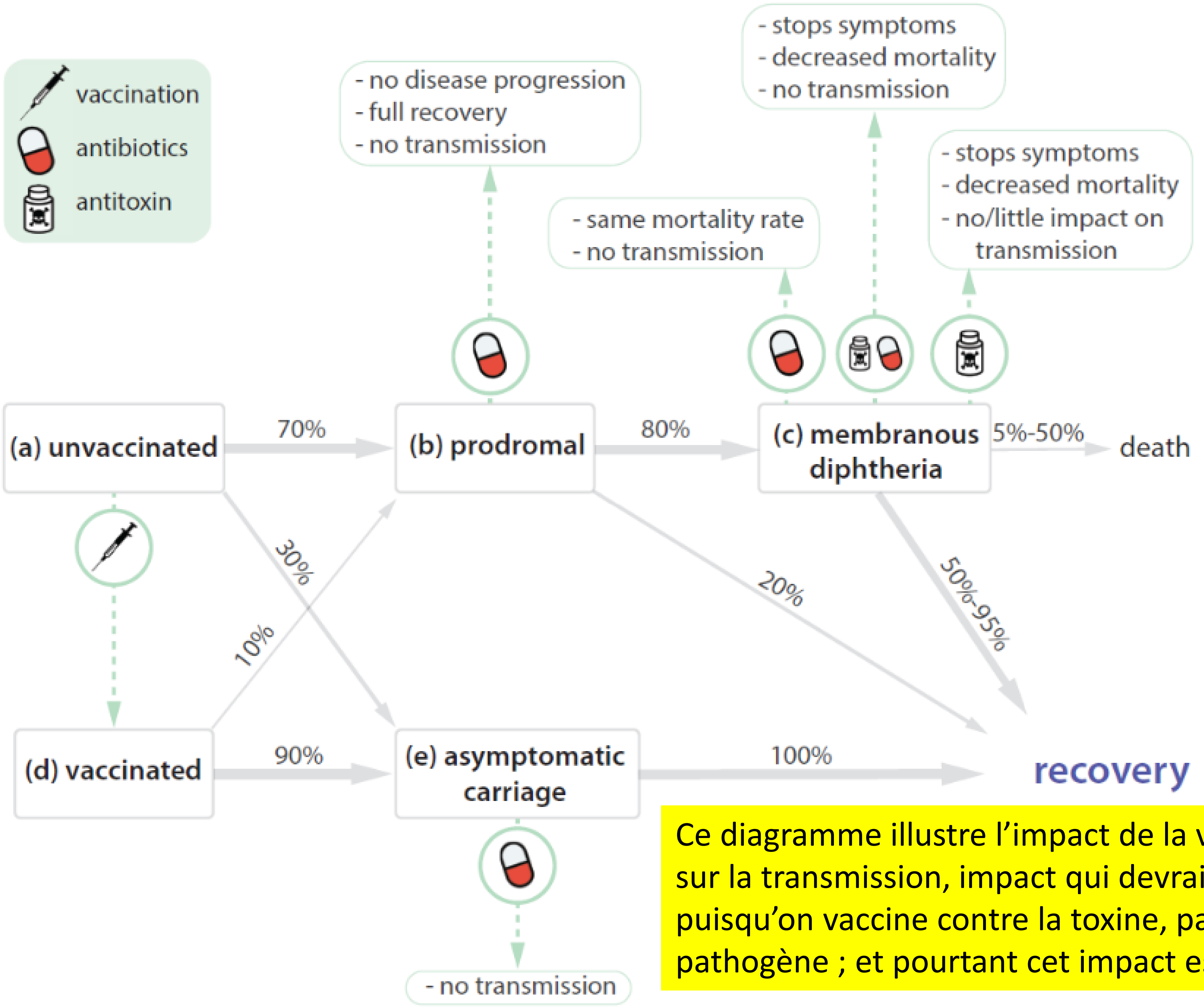
IDSA Infectious Diseases Society of America — hivma hiv medicine association — OXFORD

Clinical and Epidemiological Aspects of Diphtheria: A Systematic Review and Pooled Analysis

Shaun A. Truelove,[1,a] Lindsay T. Keegan,[1,a] William J. Moss,[1,2] Lelia H. Chaisson,[1] Emilie Macher,[3] Andrew S. Azman,[1,3] and Justin Lessler[1]

[1]Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA; [2]International Vaccine Access Center, Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA; and [3]Médecins Sans Frontières, Geneva, Switzerland

(See the Editorial Commentary by Wiedermann on pages 98–99.)



Ce diagramme illustre l’impact de la vaccination sur la transmission, impact qui devrait être faible, puisqu’on vaccine contre la toxine, pas contre le pathogène ; et pourtant cet impact est là.

Cet impact est peut-être lié au fait qu'il n'y a pas que la toxine diphtérique dans les différents vaccins, mais de nombreuses autres protéines de *C. diphtheriae*

Vaccine 37 (2019) 3061–3070

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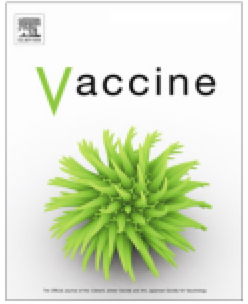
Contents lists available at ScienceDirect

Vaccine

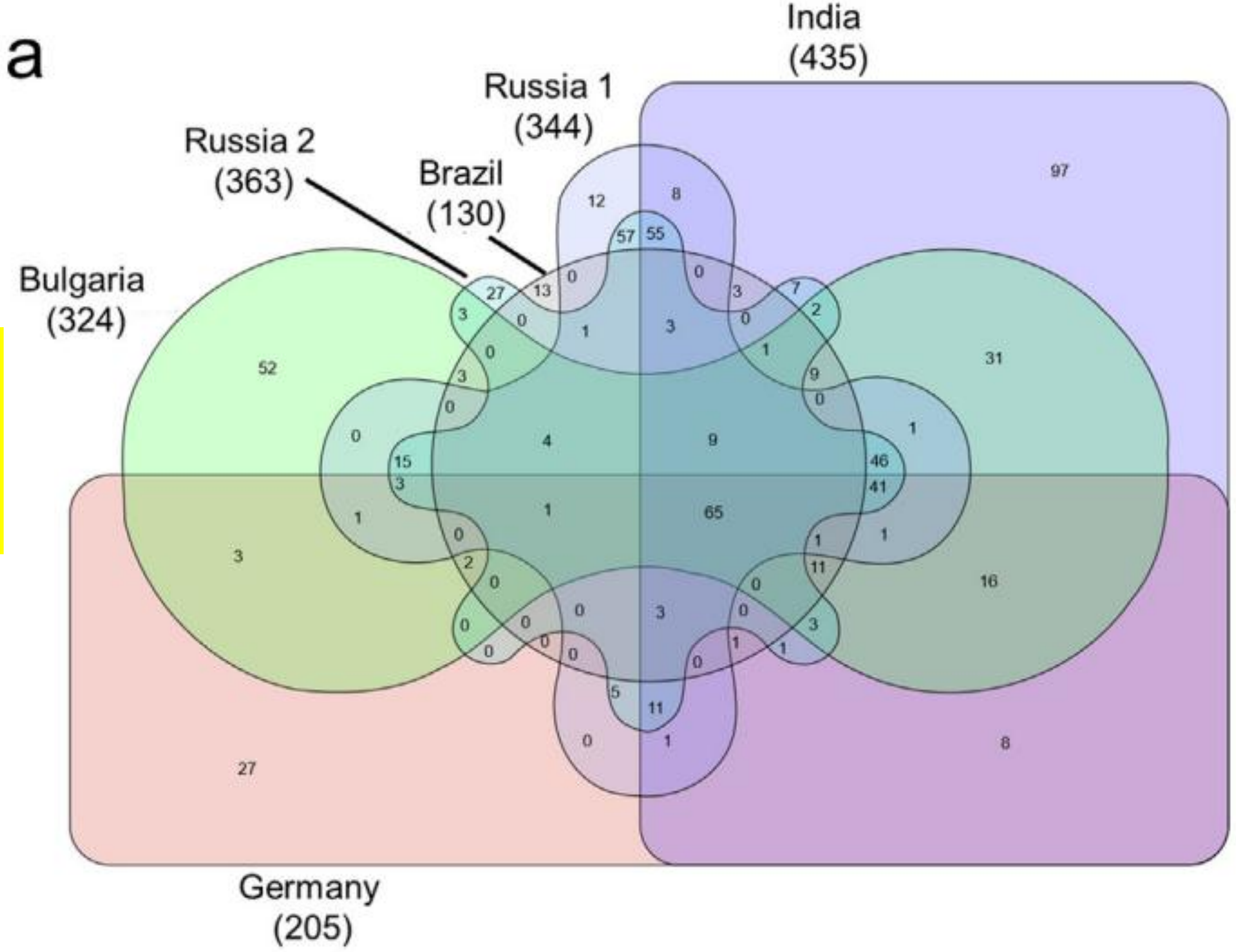
journal homepage: www.elsevier.com/locate/vaccine



Proteomics of diphtheria toxoid vaccines reveals multiple proteins that are immunogenic and may contribute to protection of humans against *Corynebacterium diphtheriae*

Jens Möller [a], Max Kraner [b], Uwe Sonnewald [b], Vartul Sangal [c], Hannes Tittlbach [d], Julia Winkler [e], Thomas H. Winkler [d], Vyacheslav Melnikov [f], Roland Lang [g], Andreas Sing [h], Ana Luiza Mattos-Guaraldi [i], Andreas Burkovski [a,*]

Les vaccins anti-diphtérie de différents pays sont des « soupes » de nombreuses protéines – avec des différences notables de composition d'un pays à l'autre



[Human Vaccines 5:5, 341-346; May 2009]; ©2009 Landes Bioscience

En France, les populations pour lesquelles les taux d'anticorps sont les plus faibles sont les seniors : faute de rappels dans les décennies précédentes.

Research Paper

Antibodies to tetanus, diphtheria and pertussis among healthy adults vaccinated according to the French vaccination recommendations

Odile Launay,[1-3] Christine Toneatti,[4] Claire Bernède,[4] Elisabeth Njamkepo,[5] Karine Petitprez,[2,3] Annie Leblond,[6] Sylvie Larnaudie,[7] Catherine Goujon,[8] Marie-Noelle Ungeheuer,[8] Faïza Ajana,[9] Christian Raccurt,[10] Jean Beytout,[11] Christian Chidiac,[12] Damien Bouhour,[13] Didier Guillemot[4,14,15] and Nicole Guiso[5,*]

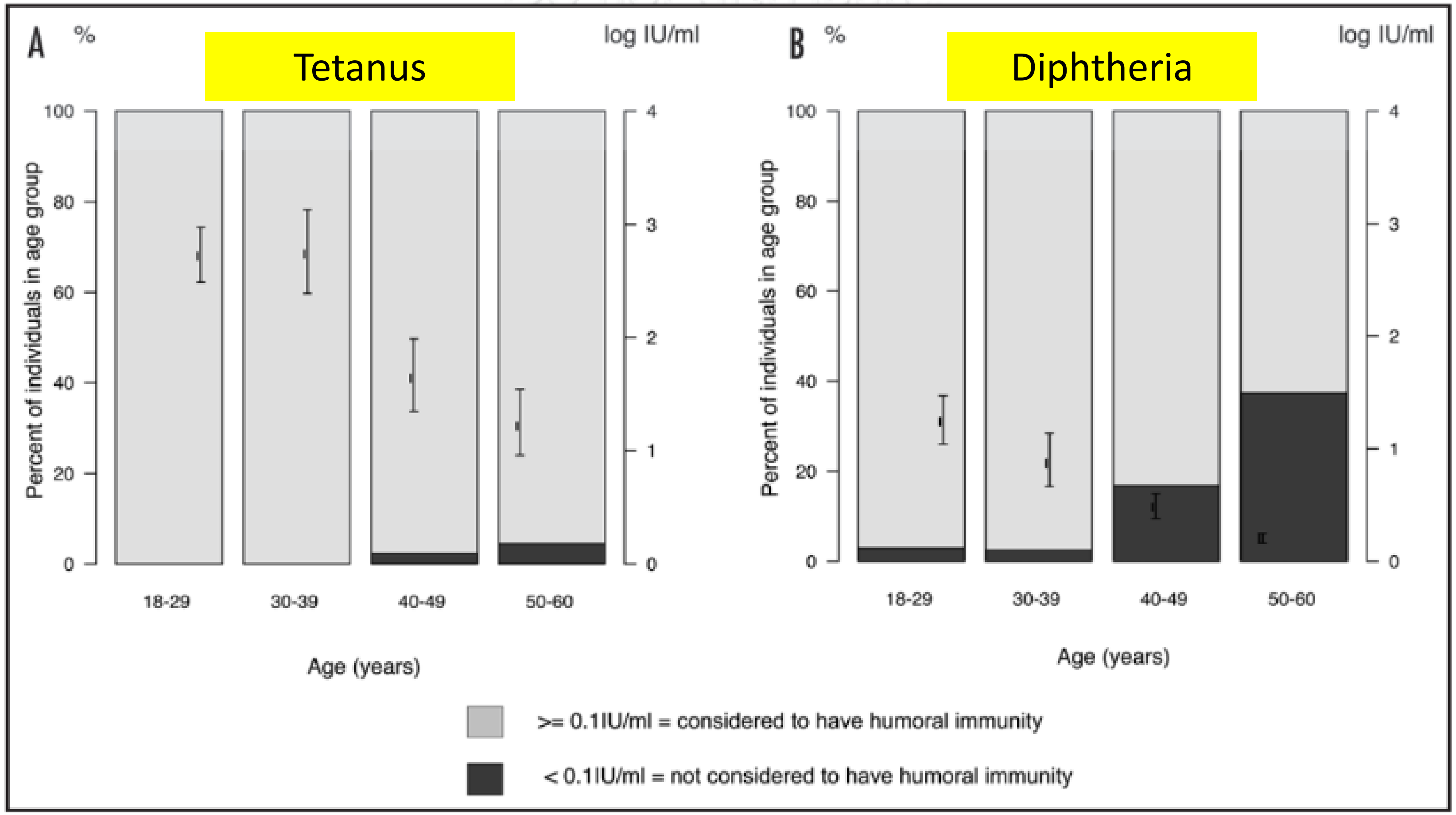


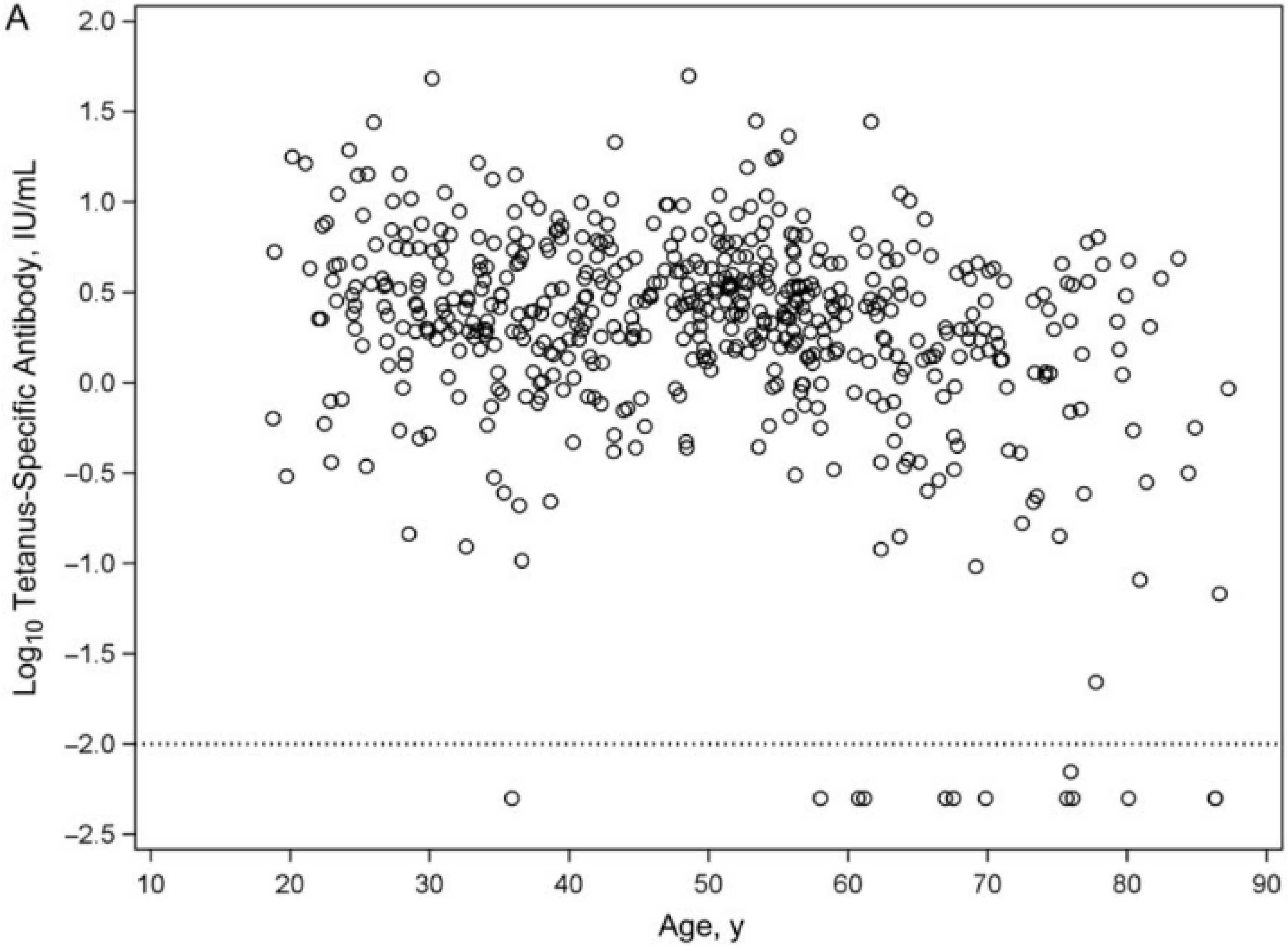
Figure 1. Concentrations of antibodies to diphtheria and tetanus toxoids. (A) Concentrations and geometric mean concentrations of anti-TT antibodies, including 95% confidence intervals, by age group. (B) Concentrations and geometric mean concentrations of anti-DT antibodies, including 95% confidence intervals, by age group.

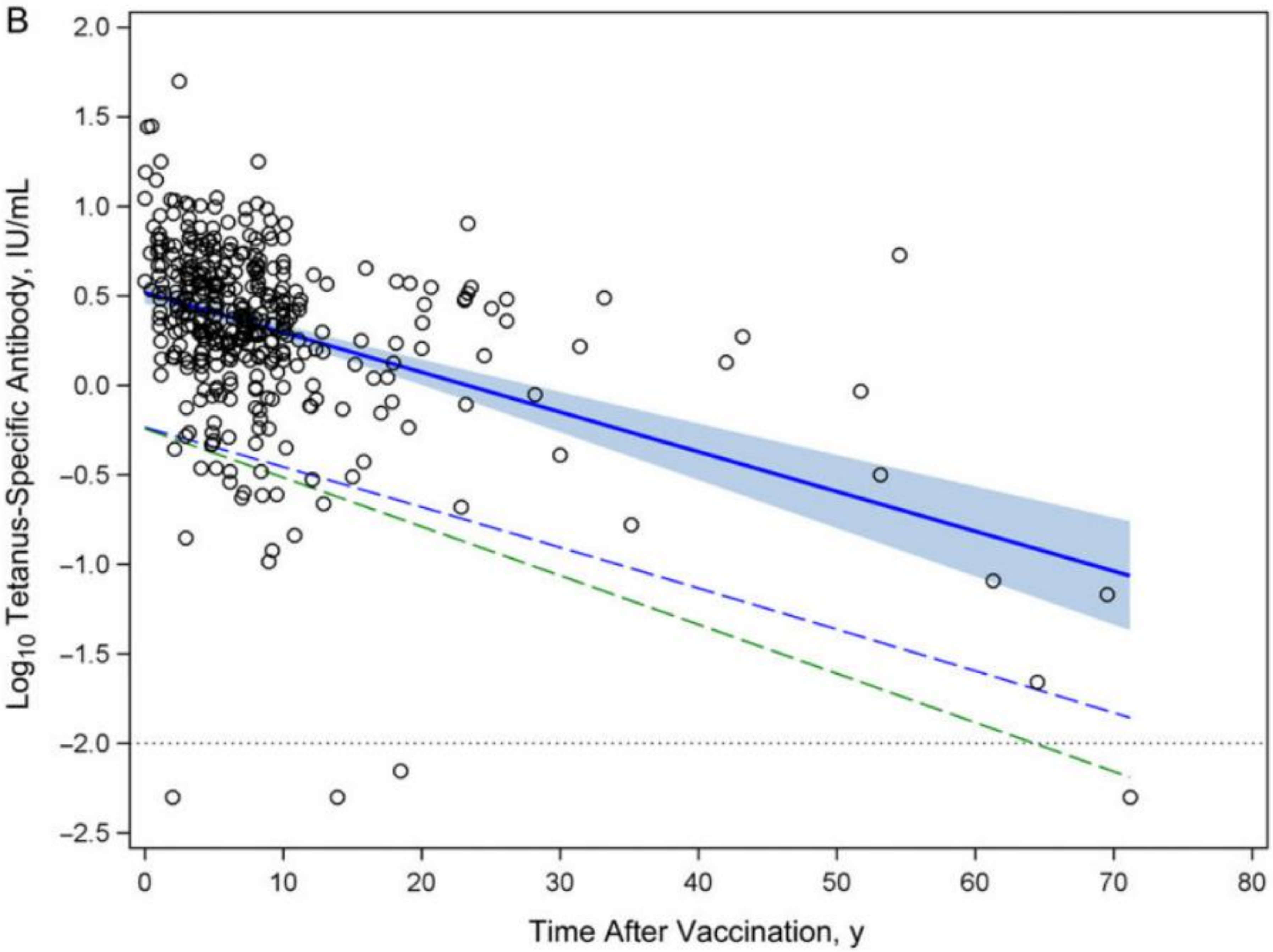
Durability of Vaccine-Induced Immunity Against Tetanus and Diphtheria Toxins: A Cross-sectional Analysis

Erika Hammarlund,[1] Archana Thomas,[1] Elizabeth A. Poore,[2] Ian J. Amanna,[2] Abby E. Rynko,[1] Motomi Mori,[3,4] Zunqiu Chen,[4] and Mark K. Slifka[1]

[1]Division of Neuroscience, Oregon National Primate Research Center, Department of Molecular Microbiology and Immunology, Oregon Health & Science University, [2]Najít Technologies, Beaverton, [3]Biostatistics Shared Resource, Knight Cancer Institute, and [4]Division of Biostatistics, Department of Public Health & Preventive Medicine, Oregon Health & Science University, Portland

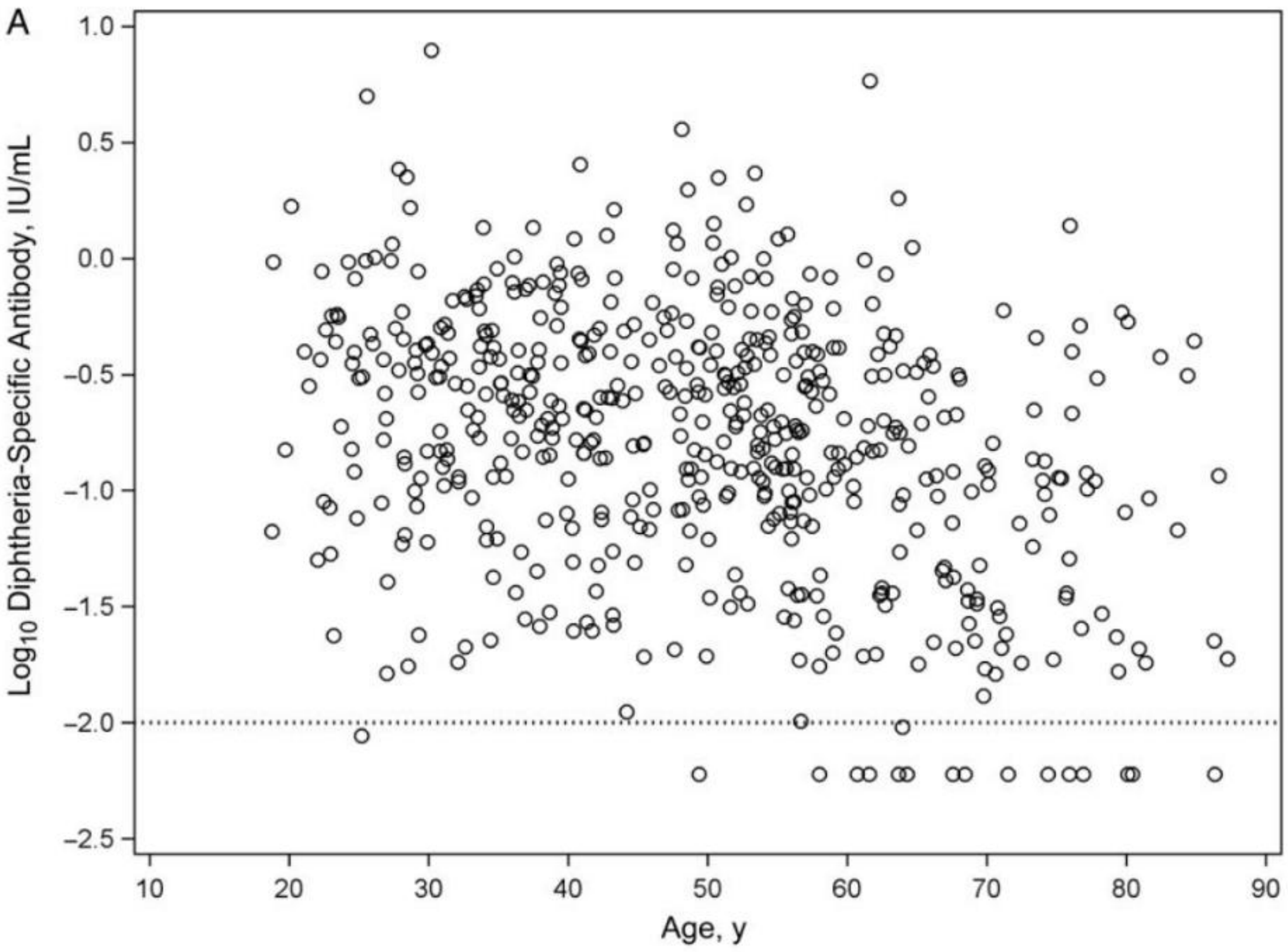
La décroissance des anticorps contre le tétanos dans les différentes classes d'âge est lente mais perceptible

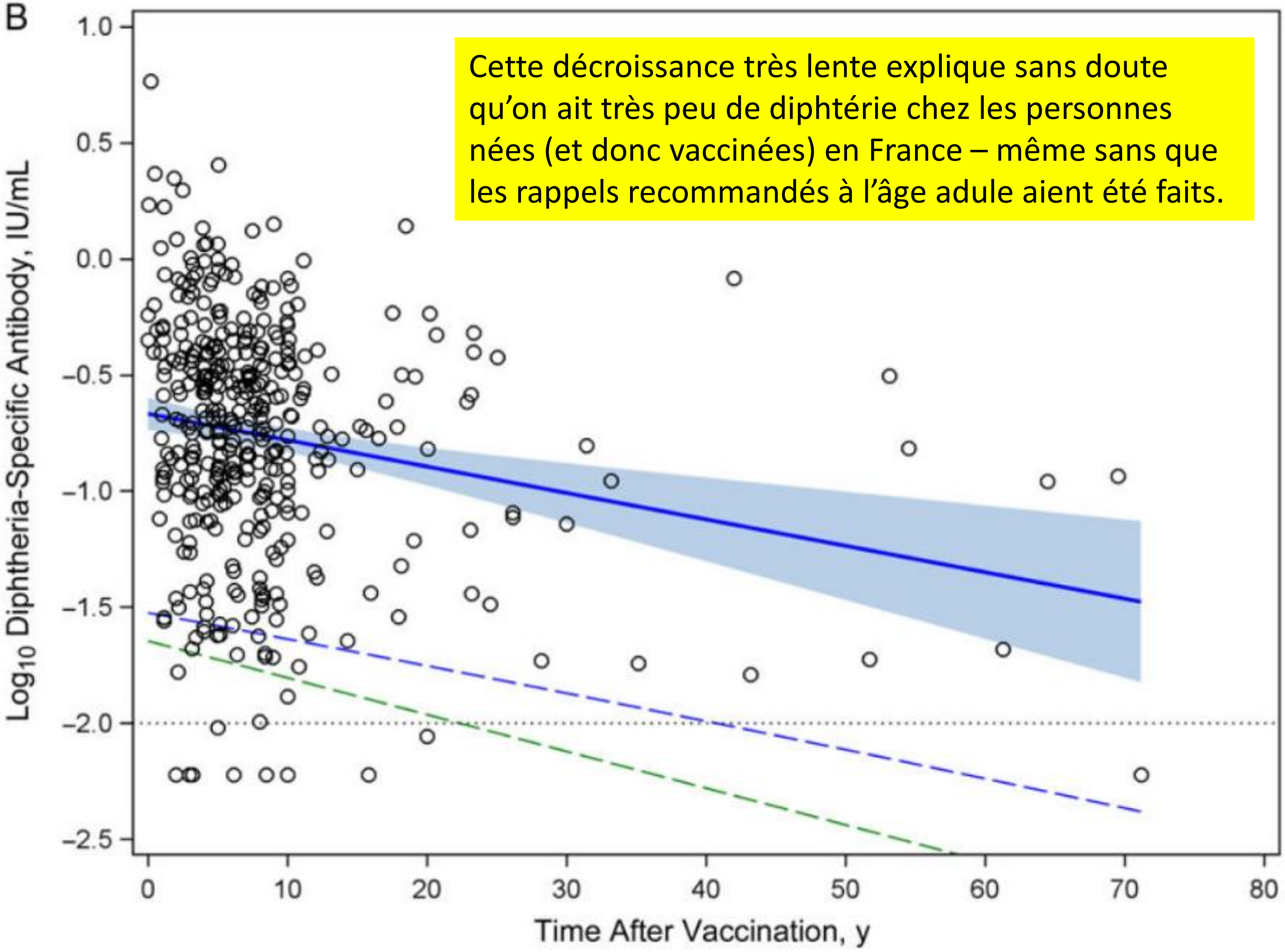




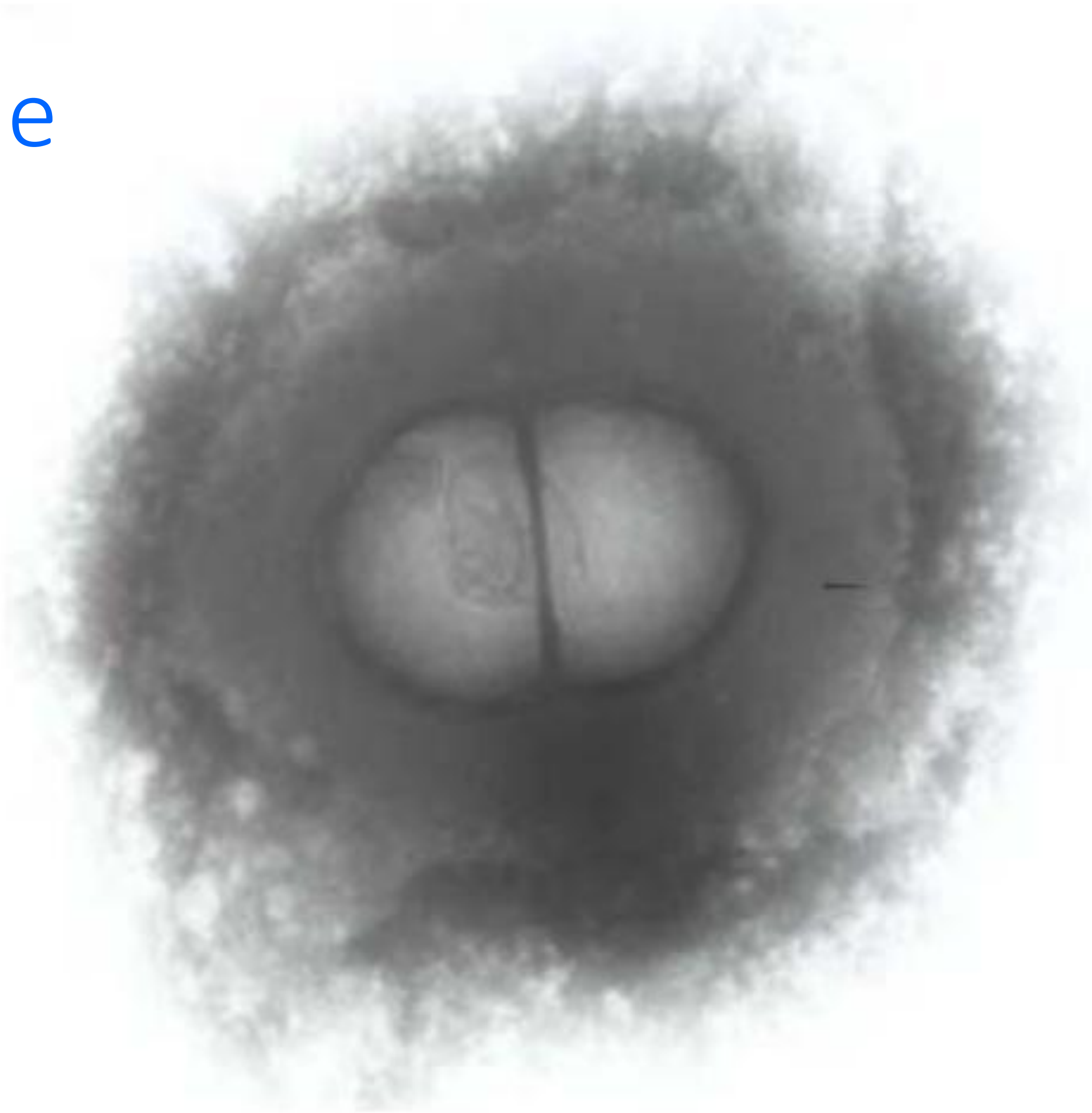
B
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
0
10
20
30
40
50
60
70
80
Log10 Tetanus-Specific Antibody, IU/mL
Time After Vaccination, y

La décroissance des anticorps contre la diphtérie est plus lente

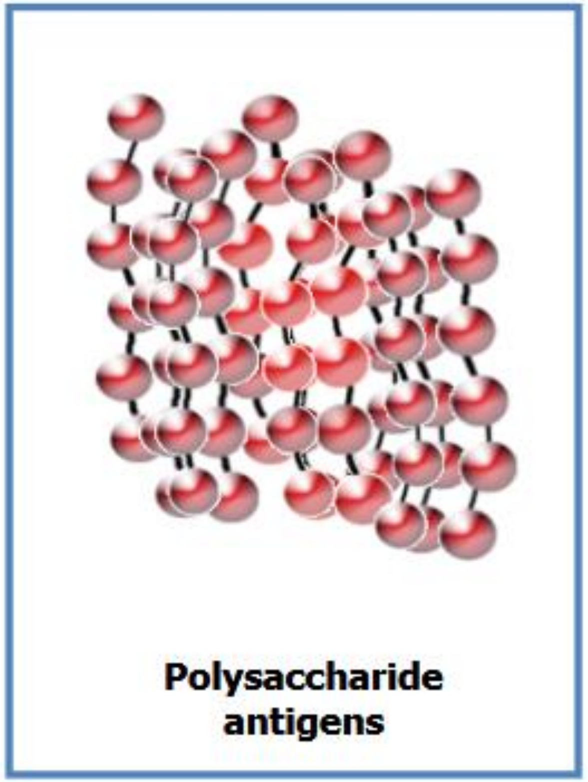



B
Cette décroissance très lente explique sans doute qu’on ait très peu de diphtérie chez les personnes nées (et donc vaccinées) en France – même sans que les rappels recommandés à l’âge adule aient été faits.
Log_{10} Diphtheria-Specific Antibody, IU/mL
Time After Vaccination, y
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
0
10
20
30
40
50
60
70
80

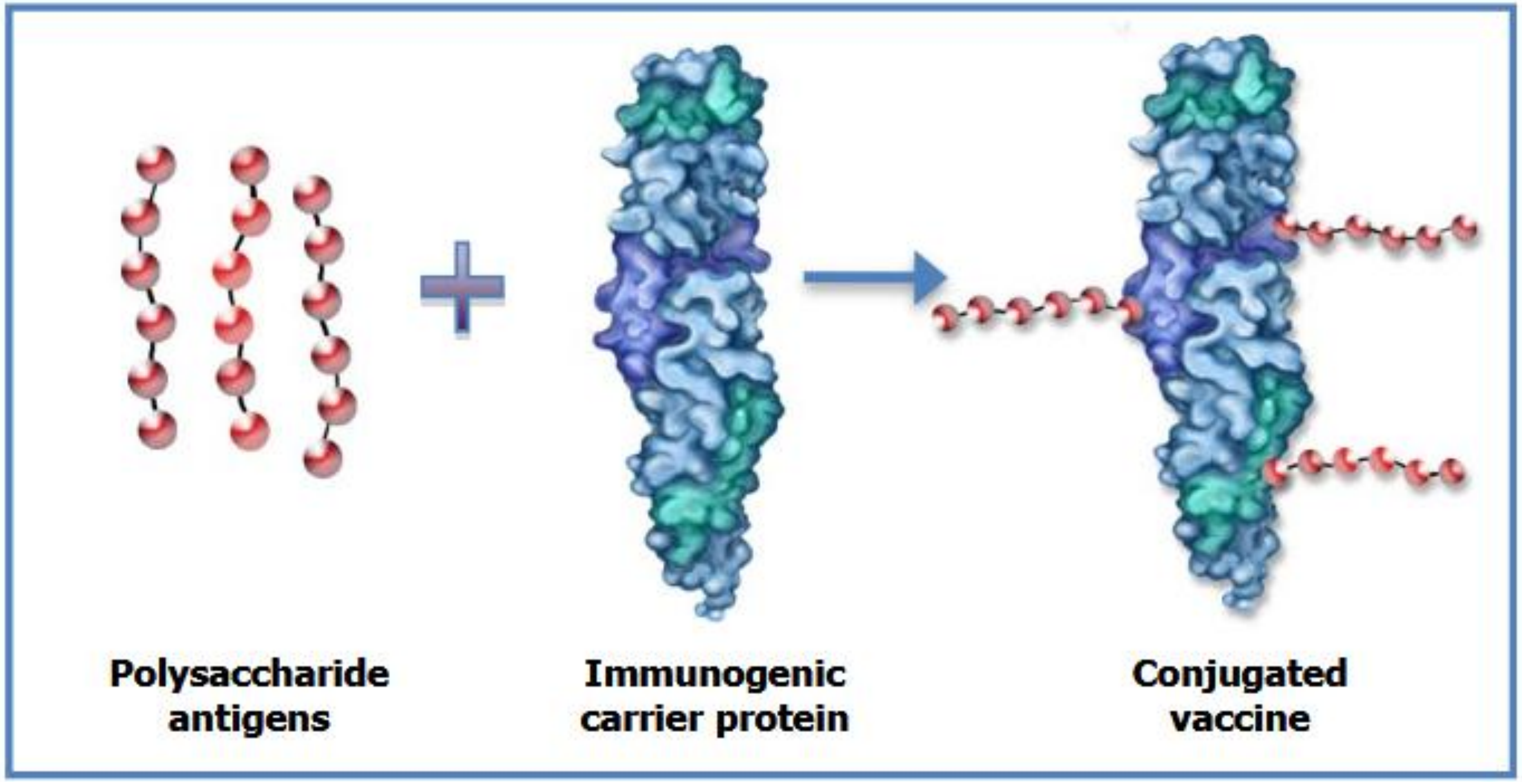
Pneumocoque et sa capsule

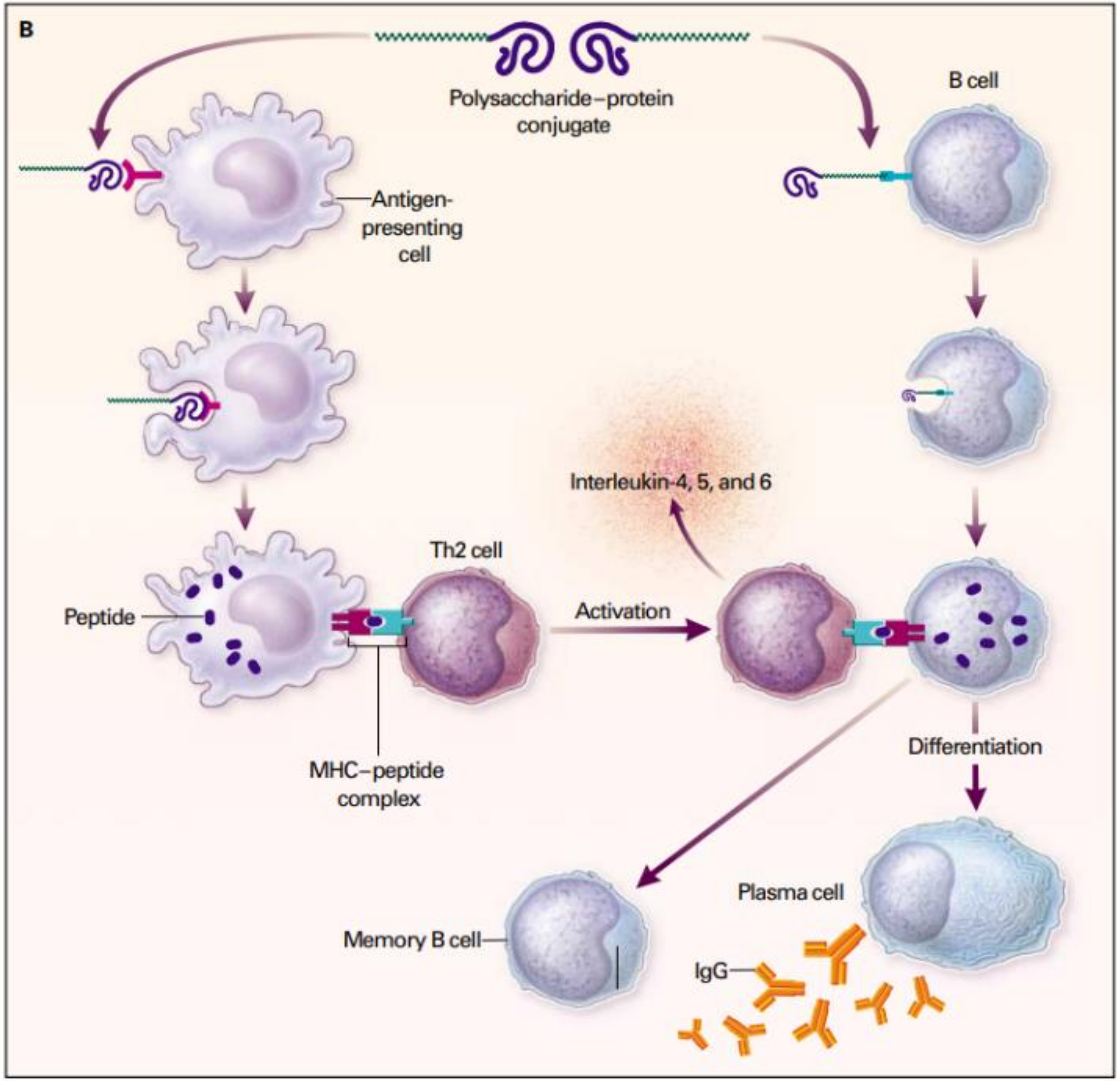


Vaccin polysaccharidique



Conjugaison liaison covalente





Les vaccins polysaccharidiques conjugués permettent d'avoir une réponse TCD4 et B, et donc une « collaboration » B-T, fondation d'une mémoire immunologique

Ada 2001

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

journal homepage: www.elsevier.com/locate/ijbiomac

Review

Cross reacting material (CRM197) as a carrier protein for carbohydrate conjugate vaccines targeted at bacterial and fungal pathogens

E.A. Khatuntseva, N.E. Nifantiev *

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- La recherche sur la vaccination anti-toxine diphtérique a permis d'identifier des anatoxines qui ne résultent pas d'une action chimique (comme historiquement) mais d'une mutation
  - La plus aboutie : CRM197

- Mutation = processus plus simple à maitriser : immunogénicité plus stable

- Ce type d'anatoxine est devenu intéressant comme protéine de conjugaison aux antigènes polysaccharidique (pneumocoque, méningocoque …)
  - profil de sécurité bien connu ;
  - les épitopes T étaient déjà validés chez l'homme ;
  - important recul clinique pour les autorités réglementaires
  - cette famille d'anatoxine diphtérique a de nombreuses lysine = sites de conjugaison pour les polysaccharides

Table 1
Human pathogen glycans targeted by CRM197-based conjugate glycovaccines which have been licensed or are under development.

Entry	Human pathogen[a]	Location[b]	Glycan structure[c]
1.	*A. baumannii*	EPS	αPse-(2→6)-βDGlc 1 ↓ 6 →3)-βDGal-(1→3)-βDGalNAc(1→
2.	*B. pseudomallei, B. mallei*	CPS	→3)-6-*deoxy*-βD-*manno*-Hep-(1→ 2 ↑ Ac
3.	*B. pseudomallei, B. mallei*	LPS	→3)-6-*deoxy*-αLTal-(1→3)-βDGlc-(1→
4.	*C. jejuni* serotype HS23/36	CPS	→3)-αDGal-(1→2)-6-*deoxy*-3-Me-α-D-*altro*-Hep-(1→3)-βDGlcNAc-(1→ 2/ 4/ 6 ↑ P(MeO)(NH$_2$)O
5.	*C. jejuni* serotype HS14	CPS	→3)-6-*deoxy*-β-D-*ido*-Hep-(1→4)-βDGlcNAc-(1→ 1 ↑ P(MeO)(NH$_2$)O
6.	*C. jejuni* serotype HS15	CPS	→3)-αLAra*f*-(1→3)-6-*deoxy*-α-L-*gulo*-Hep-(1→ 3 ↑ 1 αLAra*f*
7.	*C. albicans*	CWPS	→3)-βDGlc-(1→3)-βDGlc-(1→3)-βDGlc-(1→3)-βDGlc-(1→ 6 ↑ 1 βDGlc
8.	*C. difficile*	CWPS PS I	→4)-αLRha-(1→3)-βDGlc-(1→4)-αDGlc-(1→2)-αDGlc-(1-OPO$_2$H-O→ 3 ↑ 1 αLRha
9.	*C. difficile*	CWPS PS II	→6)-βDGlc-(1→3)-βDGalNAc -(1→4)-αDGlc-(1→4)-βDGalNAc-(1→3)-αDMan-(1-OPO$_2$H-O→ 3 ↑ 1 βDGlc
10.	*C. difficile*	CWPS PS III	OPO$_2$H-O→ ↓ 6 →6)-αDGlcNAc-(1→3)-αDGlcNAc-(1→2)-GroA
11.	*E. coli* O157:H7	LPS	→4)-αDGlc-(1→2)-αDGal-(1→3)-αDGlc-(1→ 2 3 ↑ ↑ 1 1 αDGlc αDGlcNAc
12.	*H.influensa* serotype a	CPS	→4)-βDGlc-(1→1)-D-ribitol-5-OPO$_2$H-O→
13.	*H. influensa* serotype b	CPS	→4)-βDRib*f*-(1→1)-D-ribitol-5-OPO$_2$H-O→
14.	*K. pneumoniae*	CPS	

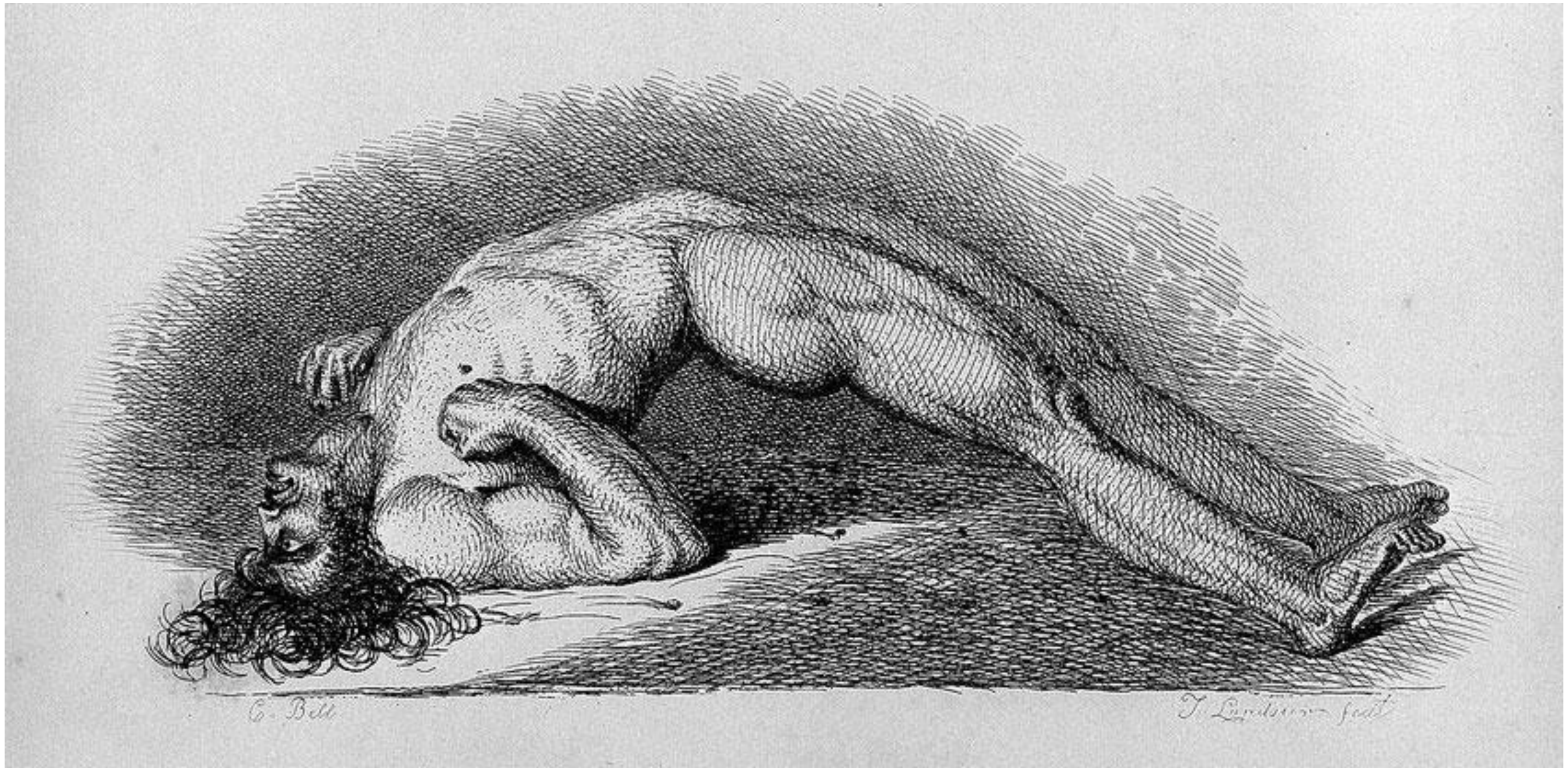
Table 1 (*continued*)

Entry	Human pathogen[a]	Location[b]	Glycan structure[c]
			→3)-βDGal-(1→3)-αDGalA-(1→2)-αLRha-(1→2)-αLRha-(1→2)-αLRha-(1→ 1 ↑ 4 αLRha
15.	*M. catarrhalis* serotypes A/B/C	LPS	αDGal-(1→4)-βDGal-(1→4)-αDGlc-(1→2)-βDGlc-(1→6)-αDGlc-(1→5)-αKdo-(2→6)- 3 4 ↑ ↑ 1 2 βDGlc αKdo
16.	*M. tuberculosis*	LPS	→6)-αDMan-(1→6)-αDMan-(1→6)-αDMan-(1→6)-αDMan-(1→6)-αDMan-(1→ 2 2 ↑ ↑ 1 1 αDAraf-(1→5)-αDAraf-(1→5)-αDAraf-(1→5)-αDAraf αDMan 3 ↑ 1 αDAraf-(1→5)-αDAraf
17.	*N. meningitidis* (all immunotypes, including MenB)	LPS	αKdo PPEtN 2 ↓ ↓ 4 4 →αDGlcNAc-(1→2)-αDHep-(1→3)-αDHep(1→5)-αKdo-(2→6)-F 4 ↑ 2 αDNeu (2→3)-βDGal-(1→4)-βDGlcNAc-(1→3)-βDGal-(1→4)-βDGlc
18.	*N. meningitidis* serogroup A (MenA)	CPS	→6)-αDManNAc-(1→OPO$_2$H-O→ 3/4 ↑ OAc
19.	*N. meningitidis* serogroup C (MenC)	CPS	→9)-αDNeu5Ac-(2→ 7/8 ↑ Ac
20.	*N. meningitidis* serogroup W (MenW)	CPS	→6)-αDGal-(1→4)-αDNeu5Ac-(2→ 7/9 ↑ Ac
21.	*N. meningitidis* serogroup X (MenX)	CPS	→4)-αDGlcNAc-(1→OPO$_2$HO→
22.	*N. meningitidis* serogroup Y (Men Y)	CPS	→6)-αDGlcp-(1→4)-αDNeu5Ac-(2→ 7/9 ↑ Ac
23.	*S. paratyphi* A	LPS	PPEtN P ↓ ↓ 4 –[2-αDMan-(1→4)-αLRha-(1→3)-αDGal-(1–]$_n$→4)-αDGlc-(1→2)-αDGal-(1→3)-αDGlc-(1→3)-αHep-(1→3)-Hep-(1→5)-αKdo 3 3 6 2 6 7 ↑ ↑ ↑ ↑ ↑ ↑ 1 Ac 1 1 1 1 αDPar αDGlc αDGlcNAc αDGlc Hep
24.	*S. typhi*	CPS	→4)-αDGalNAcA(1→ 3 ↑ Ac
25.	*S. typhimurium*	LPS	

Table 1 (*continued*)

Entry	Human pathogen[a]	Location[b]	Glycan structure[c]
			PPEtN P ↓ ↓ 4 [→2-αDMan-(1→4)-αLRha-(1→3)-αDGal-(1]n →4)-αDGlc-(1→2)-αDGal-(1→3)-αDGlc-(1→3)-αHep-(1→3)-Hep-(1→5)-αKdo 3 3 6 2 6 7 ↑ ↑ ↑ ↑ ↑ ↑ 1 Ac 1 1 1 1 αDAbe αDGlc αDGlcNAc αDGlc Hep
26.	*S. flexneri* serotype 2A	LPS	→2)-αLRha-(1→2)-αLRha-(1→3)-αLRha-(1→3)-βDGlcNAc-(1→4)-αDGlc-(1→2)-αDGal-(1→3)-αDGlc-(1→3)-αHep-(1→3)-αHep-(1→5)-αKdo 3,4 4 6 2 3 7 4 4 ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ OAc 1 Ac 1 1 1 P 2 αDGlc αDGlc αDGlcNAc αDGlcNAc(1→7)αHep αKdo
27.	*S. flexneri* serotype 6	LPS	[→2)-αLRha-(1→2)-αLRha-(1→4)-βDGalA-(1→3)-βDGalNAc-(1]n →3)-βDGlc-(1→3)-αDGlc-(1→3)-αDGlc-(1→3)-αHep-(1→3)-Hep-(1→5)-αKdo 3,4 2 7 4 ↑ ↑ ↑ ↑ OAc 1 1 PEtN αDGal-(1→2)-αDGal βDGalNAc-(1→7)-αHep
28.	*S. aureus* serotype 5	CPS	→4)-βDManNAcA-(1→4)-αLFucNAc-(1→3)-βDFucNAc-(1→ 3 ↑ Ac
29.	*S. aureus* serotype 8	CPS	→3)-βDManNAcA-(1→3)-αDFucNAc-(1→3)-αDFucNAc-(1→ 4 ↑ Ac
30.	*S. agalactiae* serotype Ia (Group B *S.* serotype Ia, GBSIa)	CPS	→4)-βDGal-(1→4)-βDGlc-(1→ 3 ↑ 1 αDNeuNAc-(2→3)-βDGal-(1→4)-βDGlcNAc
31.	*S. agalactiae* serotype Ib, (Group B *S.* serotype Ib, GBSIb)	CPS	→4)-βDGal-(1→4)-βDGlc-(1→ 3 ↑ 1 αDNeuNAc-(2→3)-βDGal-(1→3)-βDGlcNAc
32.	*S. agalactiae* serotype II (Group B *S.* serotype II, GBSII)	CPS	→2)-βDGal-(1→4)-βDGlcNAc-(1→3)-βDGal-(1→4)-βDGlc-(1→3)-βDGlc-(1→ 3 6 ↑ ↑ 1 1 αDNeuNAc βDGal
33.	*S. agalactiae* serotype III (Group B *S.* serotype III, GBSIII)	CPS	→6)-βDGlcNAc-(1→3)-βDGal-(1→4)-βDGlc-(1→ 4 ↑ 1 αDNeuNAc-(2→3)-βDGal
34.	*S. agalactiae* serotype IV (Group B *S.* serotype IV, GBSIV)	CPS	→4)-βDGlc-(1→4)-βDGal-(1→4)-βDGlc-(1→ 6 ↑ 1 αDNeuNAc-(2→3)-βDGal-(1→4)-βDGlcNAc
35.	*S. agalactiae* serotype V (Group B *S.* serotype V, GBSV)	CPS	→4)-βDGlc-(1→4)-βDGal-(1→4)-βDGlc-(1→ 6 3 ↑ ↑ 1 1 αDNeuNAc-(2→3)-βDGal-(1→4)-βDGlcNAc βDGlc
36.	*S. pneumonia* serotype 1	CPS	

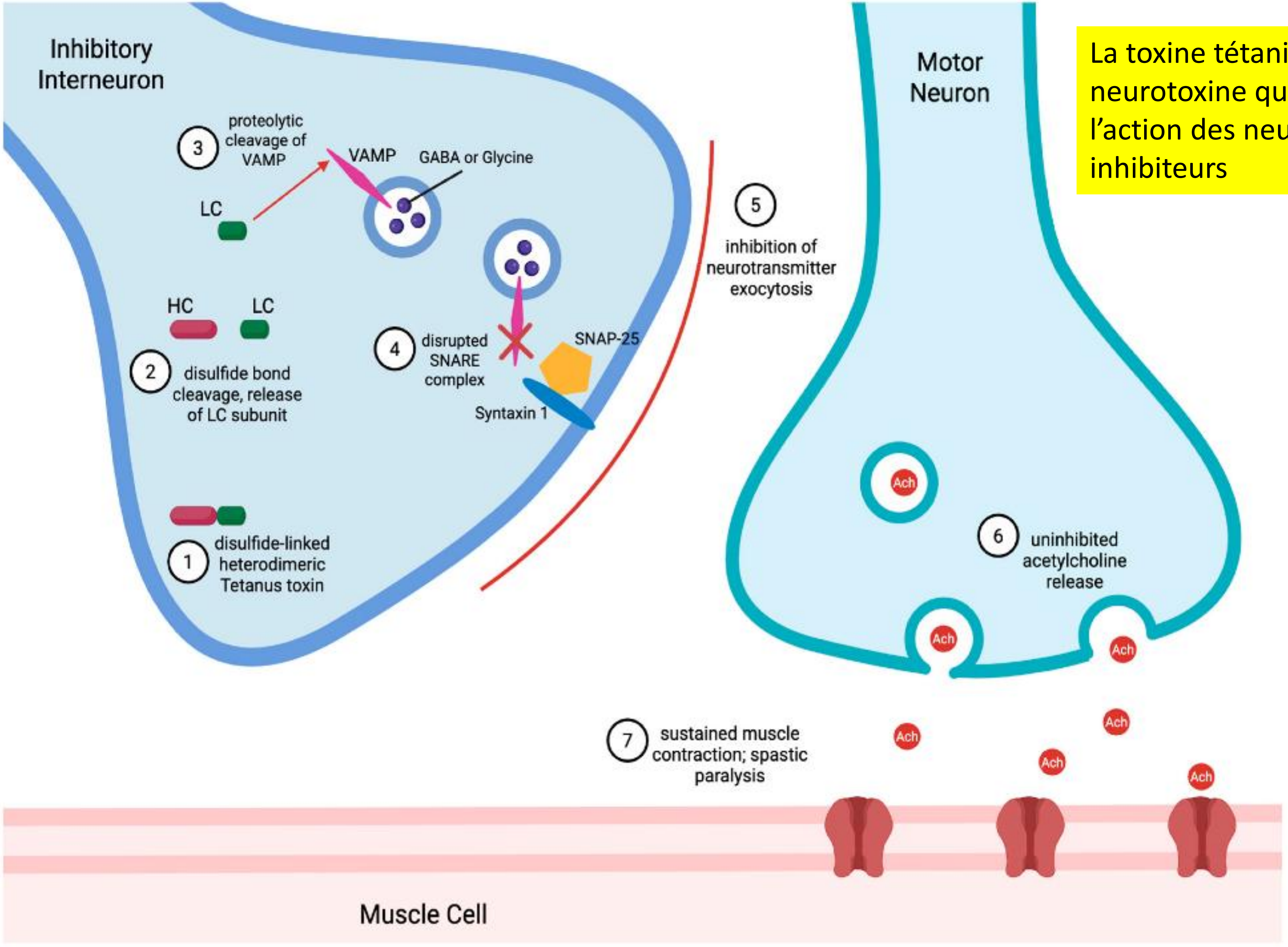
Tétanos





Élimination du tétanos maternel et néonatal en Amérique latine et dans les Caraïbes

La toxine tétanique est une neurotoxine qui inhibe l’action des neurones inhibiteurs



Stala 2026

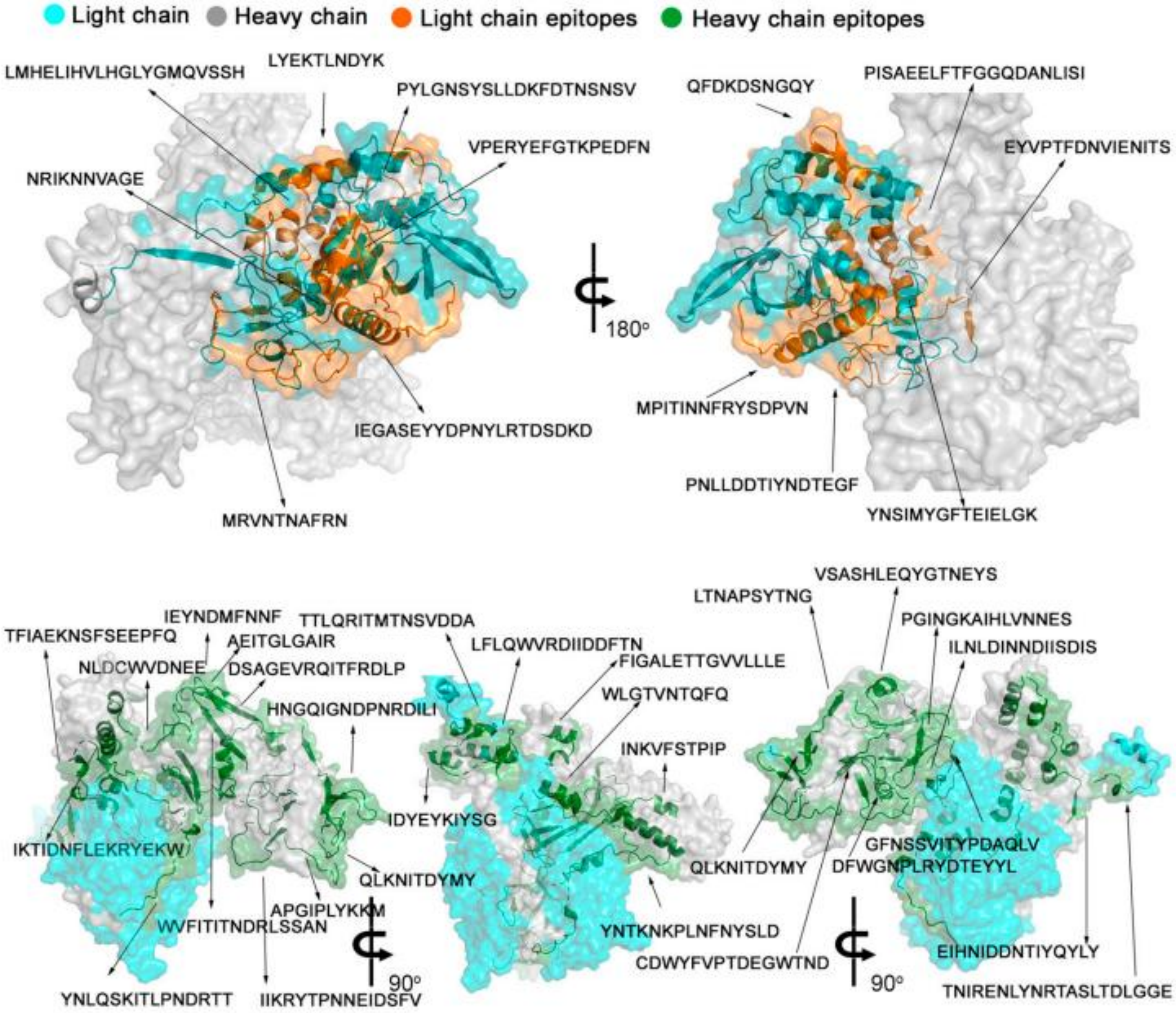
toxins

MDPI

Article

High-Throughput IgG Epitope Mapping of Tetanus Neurotoxin: Implications for Immunotherapy and Vaccine Design

Salvatore G. De-Simone [1,2,3,*], Paloma Napoleão-Pêgo [1,2], Guilherme C. Lechuga [1,2], João P. R. S. Carvalho [1,2,3], Larissa R. Gomes [1,2], Sergian V. Cardozo [4], Carlos M. Morel [1], David W. Provance, Jr. [1,2] and Flavio R. da Silva [1,2]


Light chain
Heavy chain
Light chain epitopes
Heavy chain epitopes
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PYLGNSYSLLDKFDTNSNSV
VPERYEFGTKPEDFN
NRIKNNVAGE
IEGASEYYDPNYLRTDSDKD
MRVNTNAFRN
180°
QFDKDSNGQY
PISAEELFTFGGQDANLISI
EYVPTFDNVIENITS
MPITINNFRYSDPVN
PNLLDDTIYNDTEGF
YNSIMYGFTEIELGK
TFIAEKNSFSEEPFQ
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IKTIDNFLEKRYEKW
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APGIPLYKKM
WVFITITNDRLSSAN
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90°
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FIGALETTGVVLLLE
WLGTVNTQFQ
INKVFSTPIP
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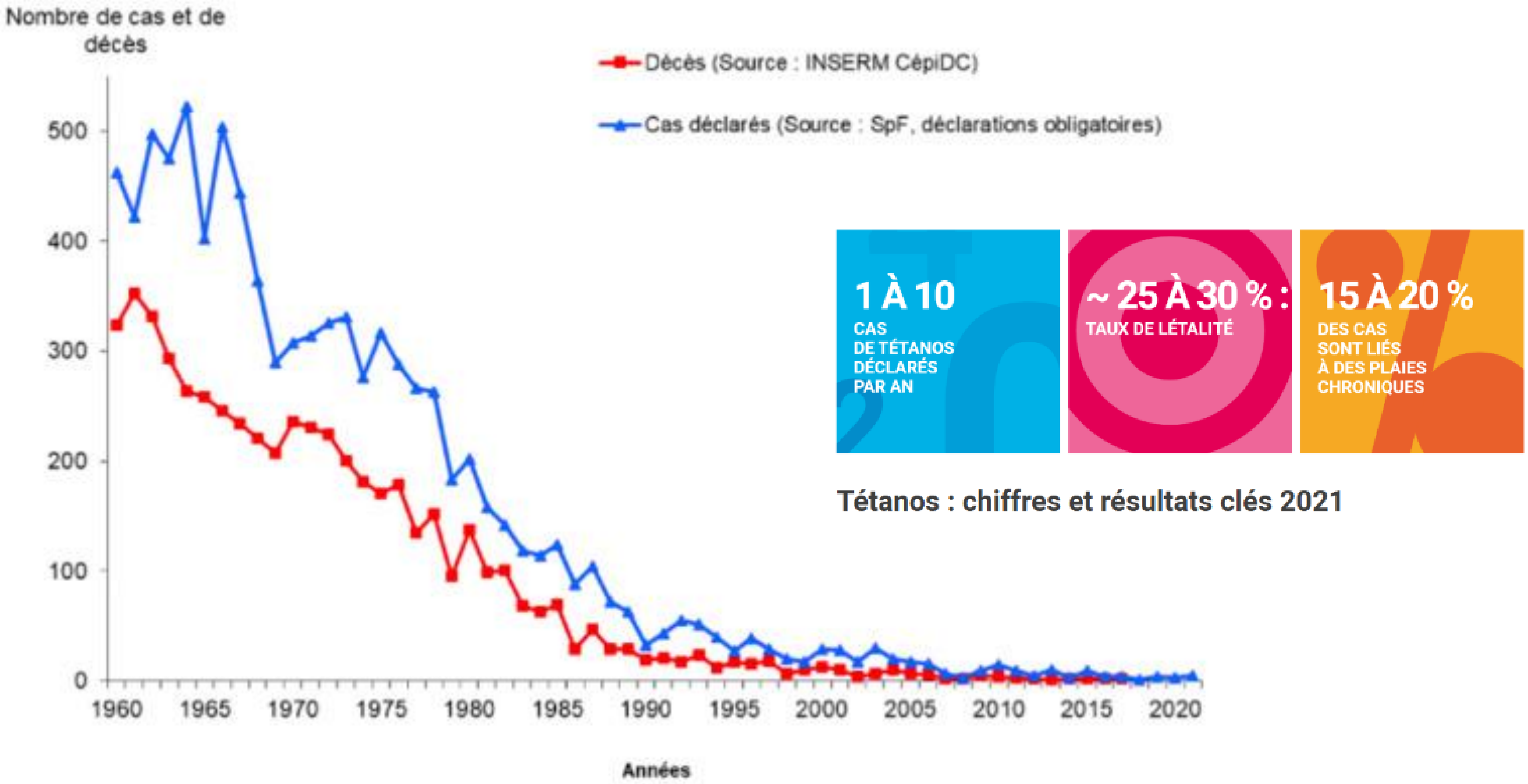
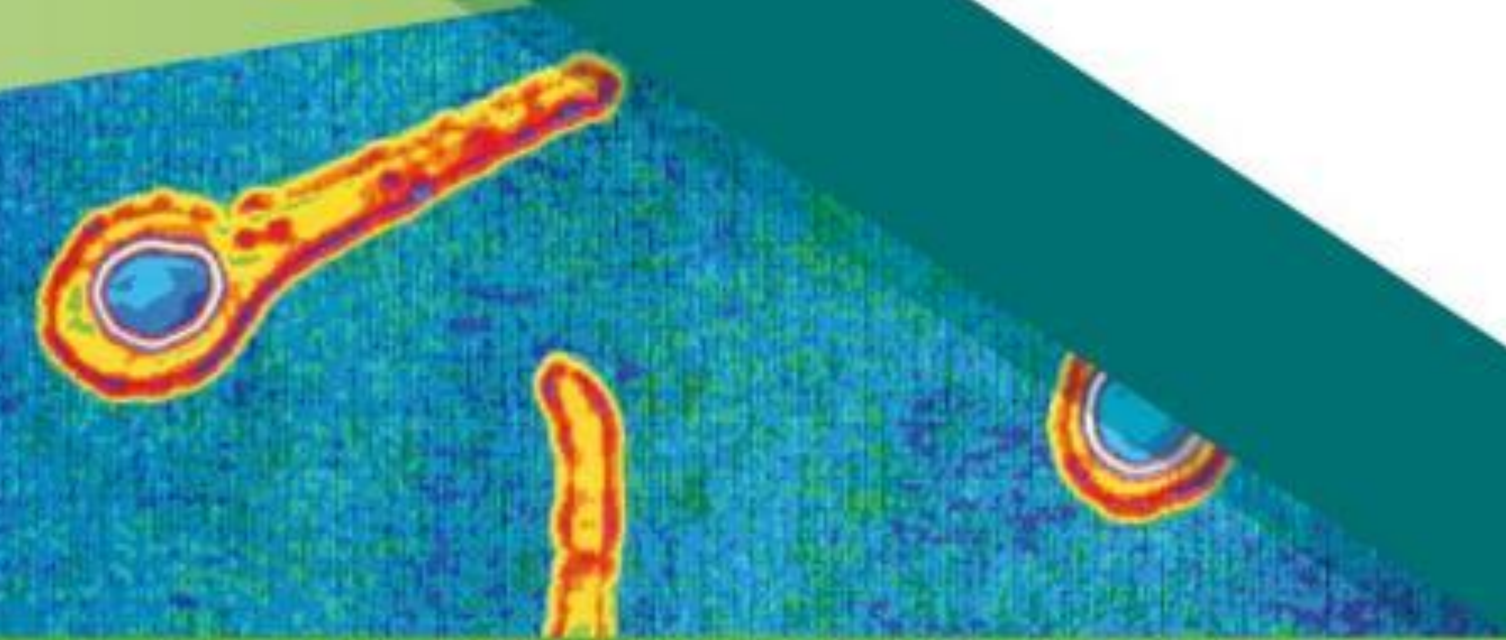
Tétanos en France



Tétanos : chiffres et résultats clés 2021

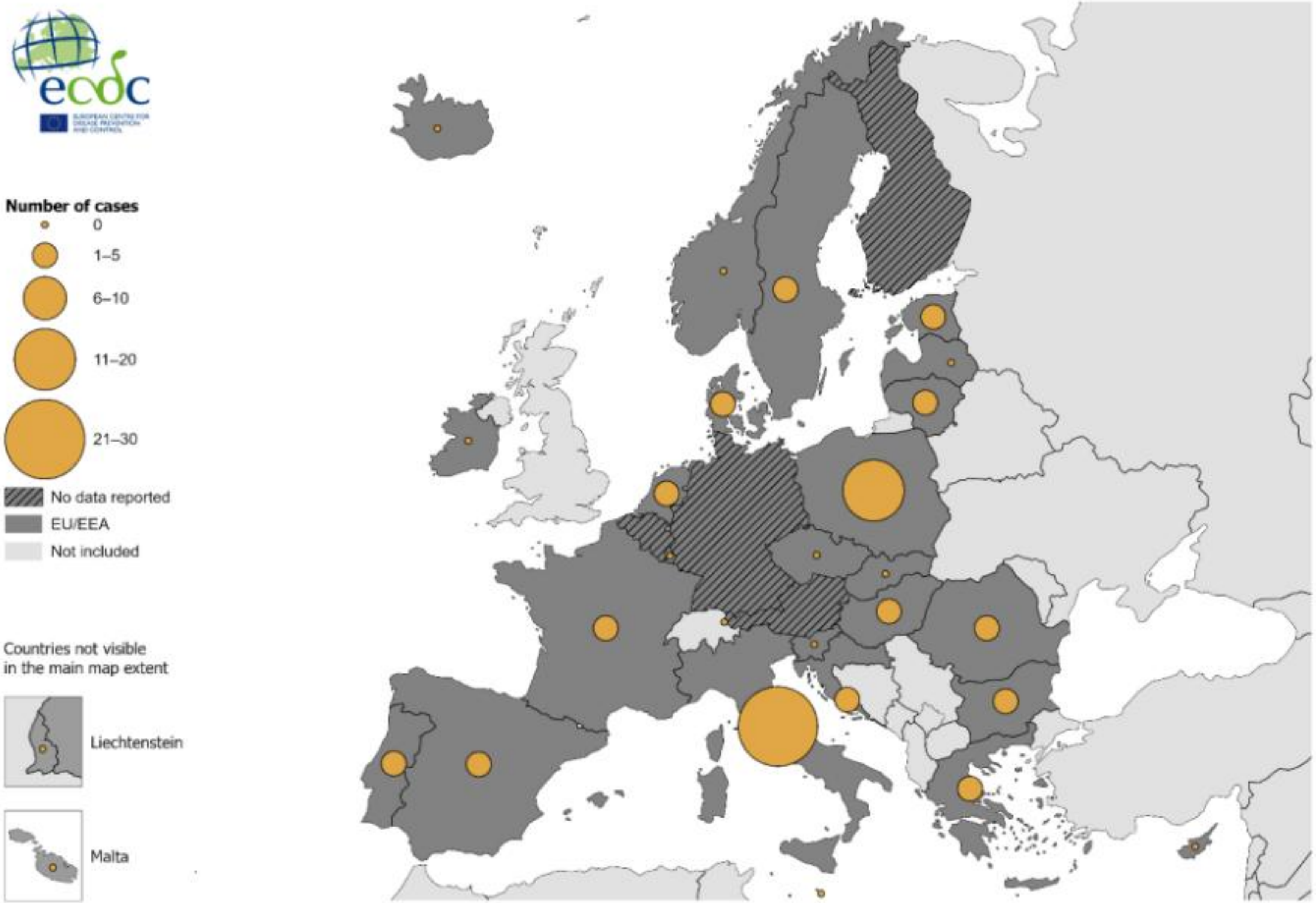


SURVEILLANCE REPORT

Tetanus

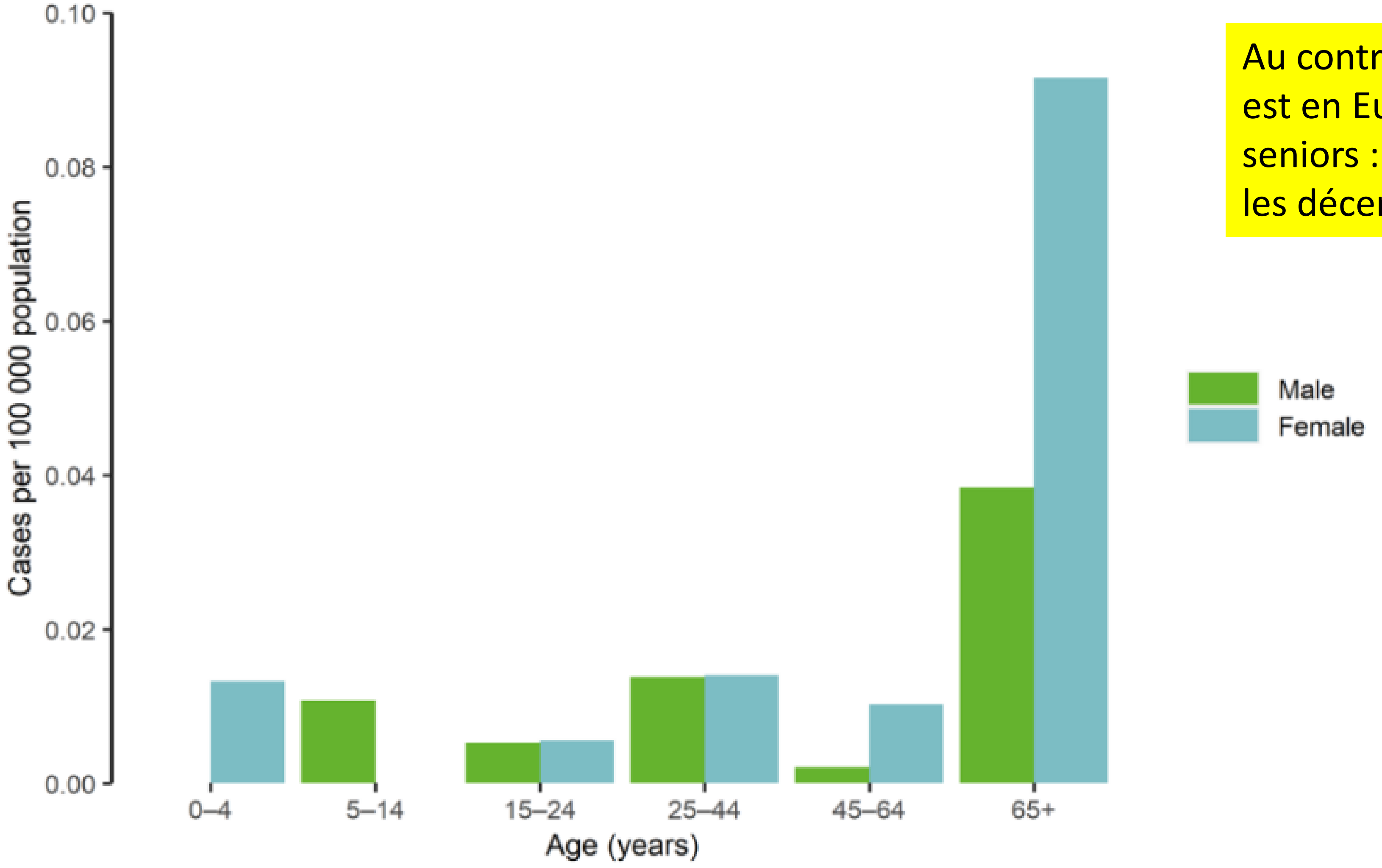
Annual Epidemiological Report for 2023

Figure 1. Tetanus cases by country, EU/EEA, 2023



Administrative boundaries: © EuroGeographics. The boundaries and names shown on this map do not imply official endorsement or acceptance by the European Union. Map produced by ECDC on 14 March 2025

Figure 2. Tetanus cases per 100 000 population, by age and gender, EU/EEA, 2023



Au contraire de la diphtérie, le tétanos est en Europe une maladie plutôt des seniors : faute de rappels vaccinaux dans les décennies précédentes.

Source: Country reports from Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, France, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

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Vaccine 25 (2007) 1304–1309

Vaccine

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Tetanus in the elderly—An important preventable disease in Australia

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Received 29 May 2006; received in revised form 25 September 2006; accepted 28 September 2006
Available online 12 October 2006

Même chose en Australie

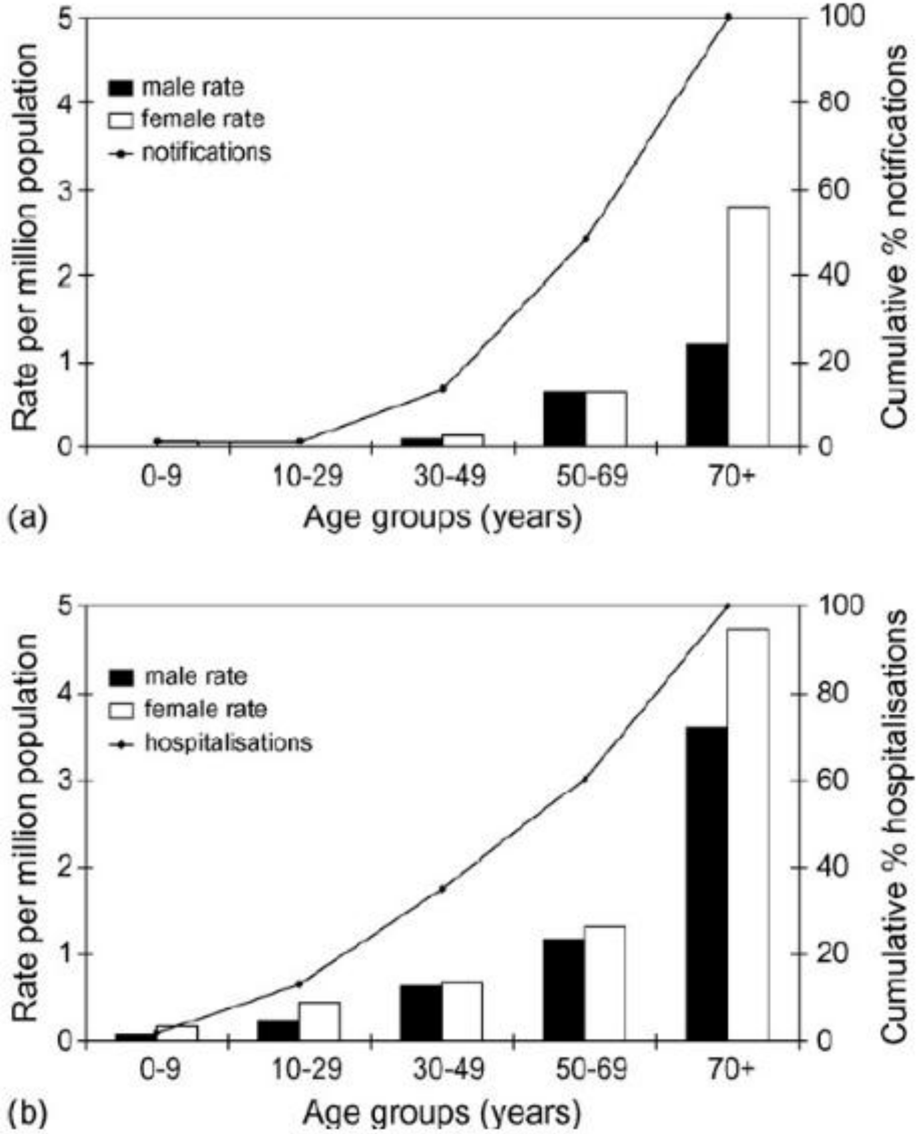


Fig. 1. Age group/sex specific average annual notification (a) and hospitalisation (b) rates. Based on notifications of tetanus with an onset date between July 1, 1993 and June 30, 2002 and hospitalisations of tetanus with a separation date between July 1, 1993 and June 30, 2002. The cumulative percentage of notifications (a) and hospitalisations (b) is also shown.

Les seniors sont progressivement devenus la principale population à faire du tétanos

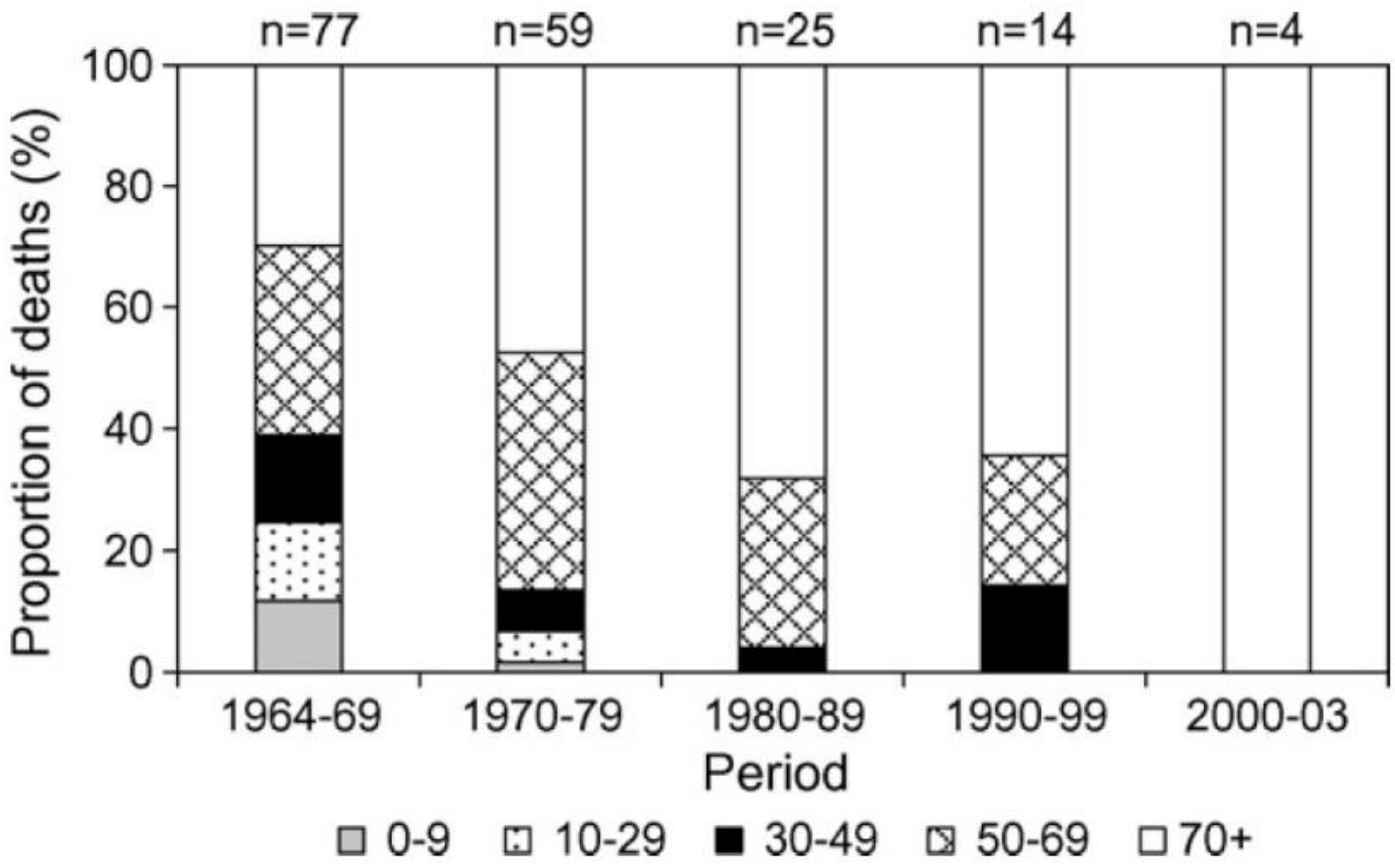


Fig. 2. The proportion of deaths caused by tetanus between January 1, 1964 and December 31, 2003, by age group. The total number of deaths (n) is indicated for each period.

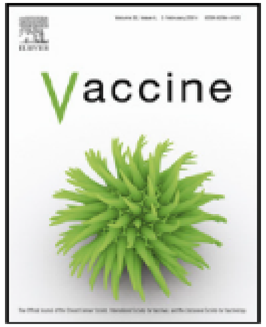
Même chose en Italie

Vaccine 32 (2014) 639–644

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine



Tetanus in Italy 2001–2010: A continuing threat in older adults

Antonietta Filia[a,*], Antonino Bella[a], Christina von Hunolstein[b], Antonella Pinto[b], Giovanna Alfarone[c], Silvia Declich[a], Maria Cristina Rota[a]

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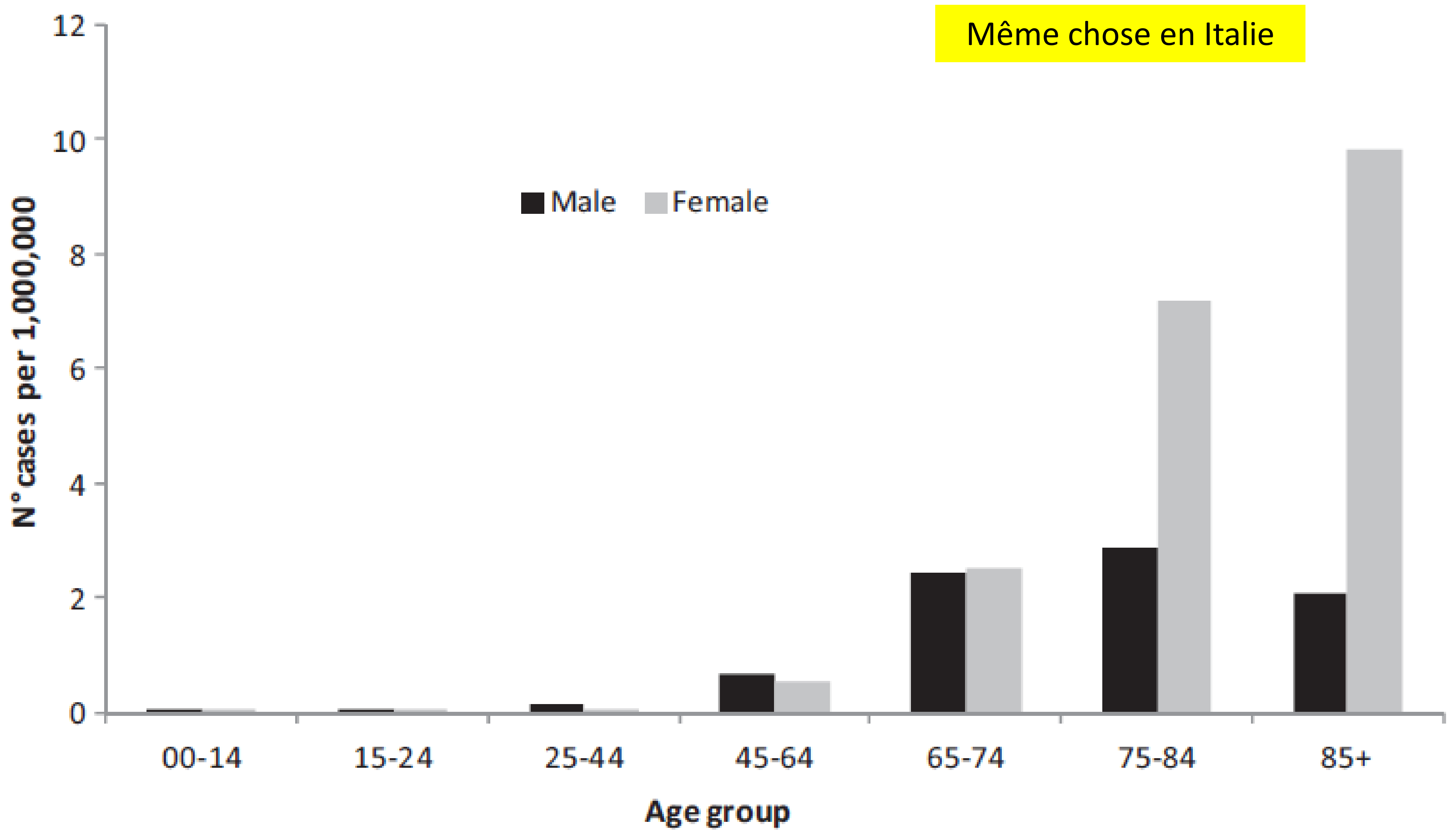


Fig. 2. Incidence of notified tetanus cases by age group and gender, Italy 2001–2010.

Cette incidence chez les seniors correspond à un moindre taux d’anticorps

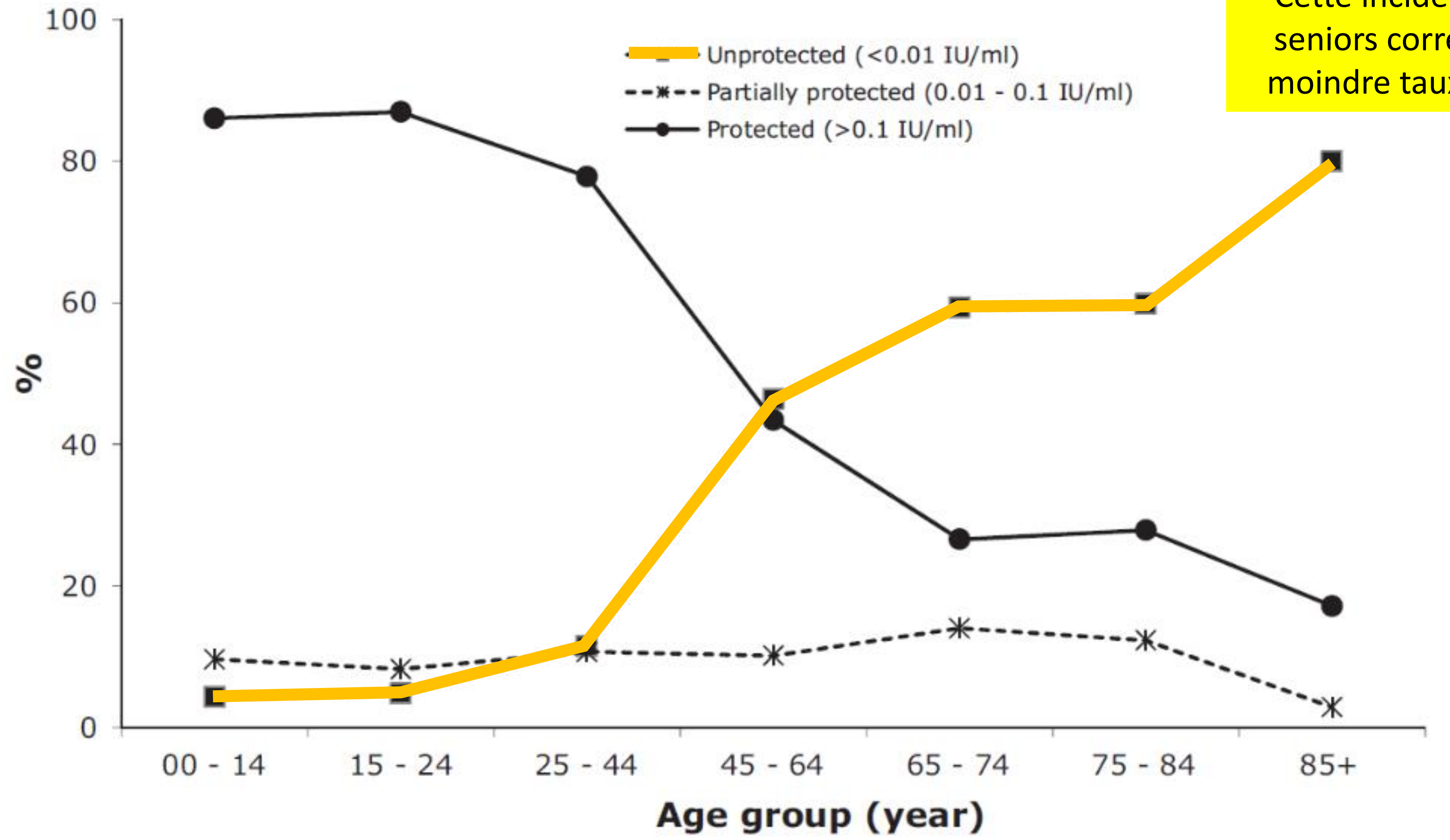


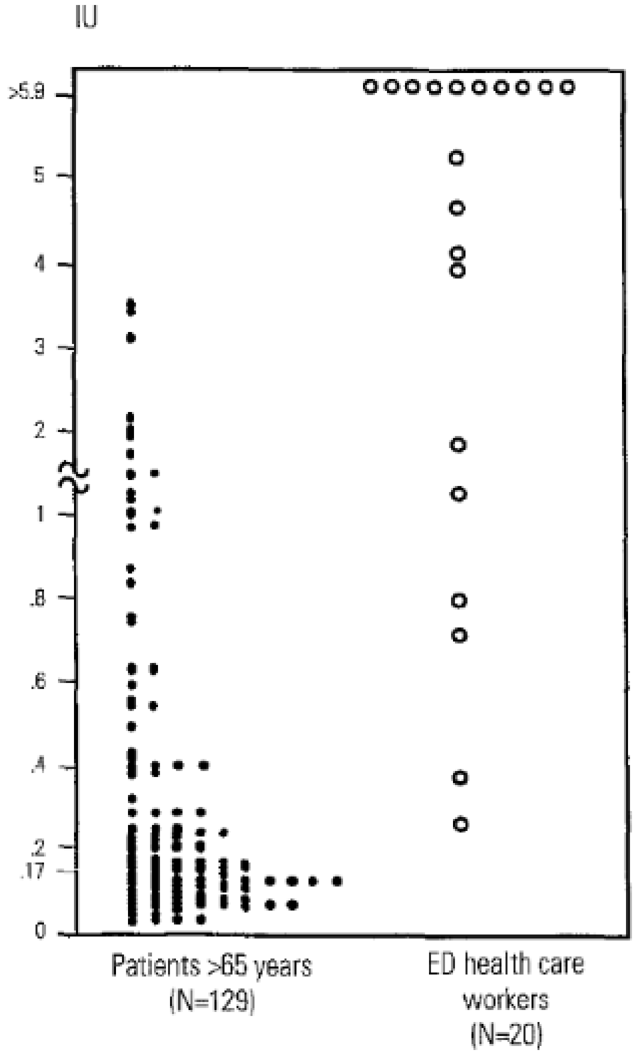
Fig. 3. Percentage of subjects with protective, partially protective and non-protective tetanus antibody levels, by age-group, Italy.

Seroprevalence of Tetanus Antibodies Among Adults Older Than 65 Years

[redacted]

Kumar Alagappan, MD*
William Rennie, MD*
Thomas Kwiatkowski, MD*
Jon Falck, MD*
Felix Silverstone, MD‡
Robert Silverman, MD*

Figure.
Tetanus antibody levels for patients older than 65 years compared with ED health care workers aged 25 to 40 years. The level considered protective is .17 IU.



Même chose dans cette étude aux USA : les taux d'Ac anti-tétaniques sont beaucoup plus faibles chez les seniors

1996

The New England
Journal of Medicine

Volume 332 MARCH 23, 1995 Number 12

A POPULATION-BASED SEROLOGIC SURVEY OF IMMUNITY TO TETANUS IN THE UNITED STATES

PETER J. GERGEN, M.D., M.P.H., GERALDINE M. MCQUILLAN, PH.D., MICHELE KIELY, DR.P.H.,
TRENA M. EZZATI-RICE, M.S., ROLAND W. SUTTER, M.D., M.P.H.&T.M., AND GABRIEL VIRELLA, M.D., PH.D.

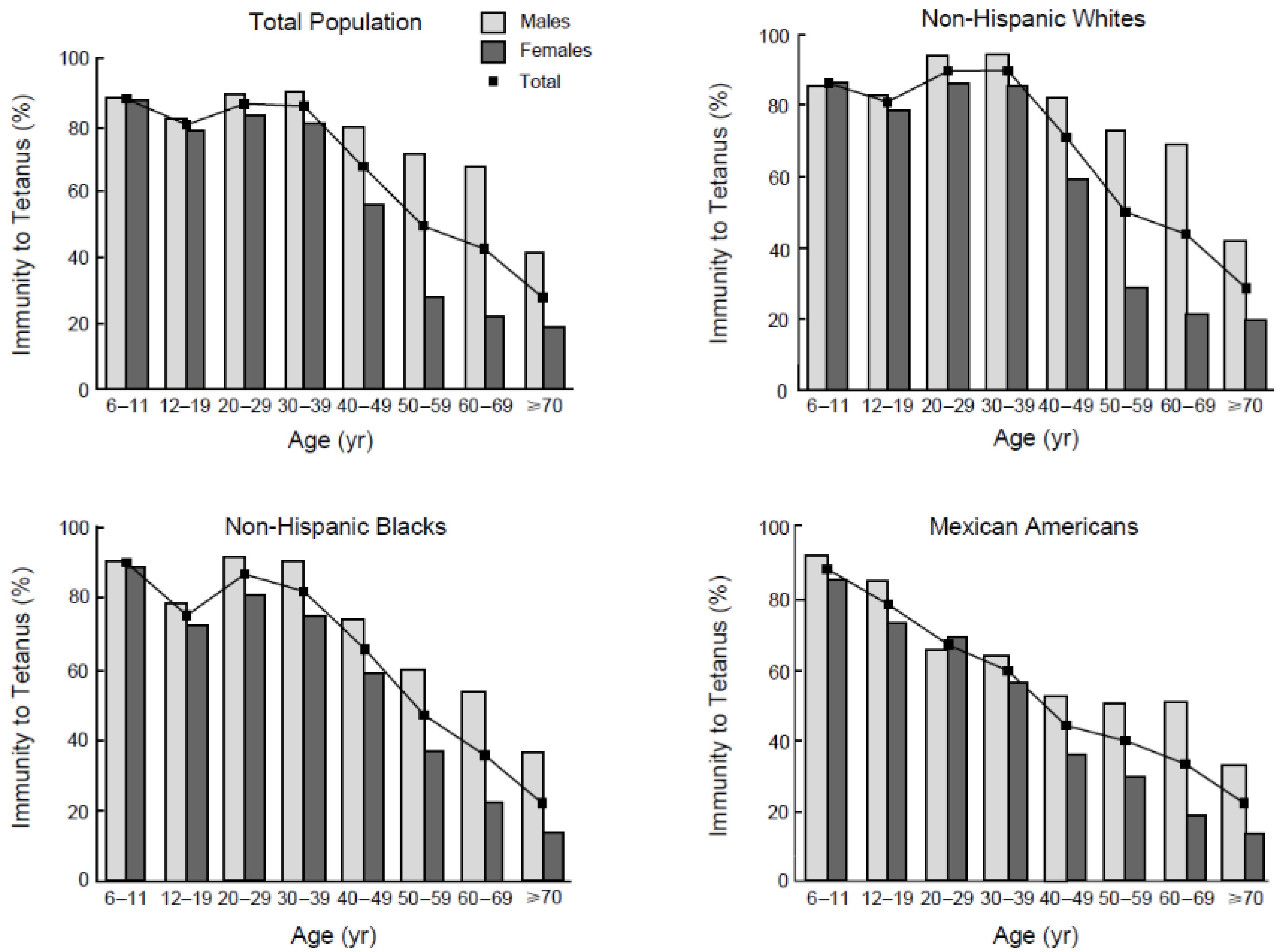


Figure 1. Age-Specific Prevalence of Immunity to Tetanus According to Racial and Ethnic Group in the NHANES III Population, 1988 to 1991.

Ces différences de taux d'anticorps selon l'âge sont encore plus marquées dans certaines ethnicités

Et comme dans d'autres pays, les seniors sont les plus touchés par le tétanos

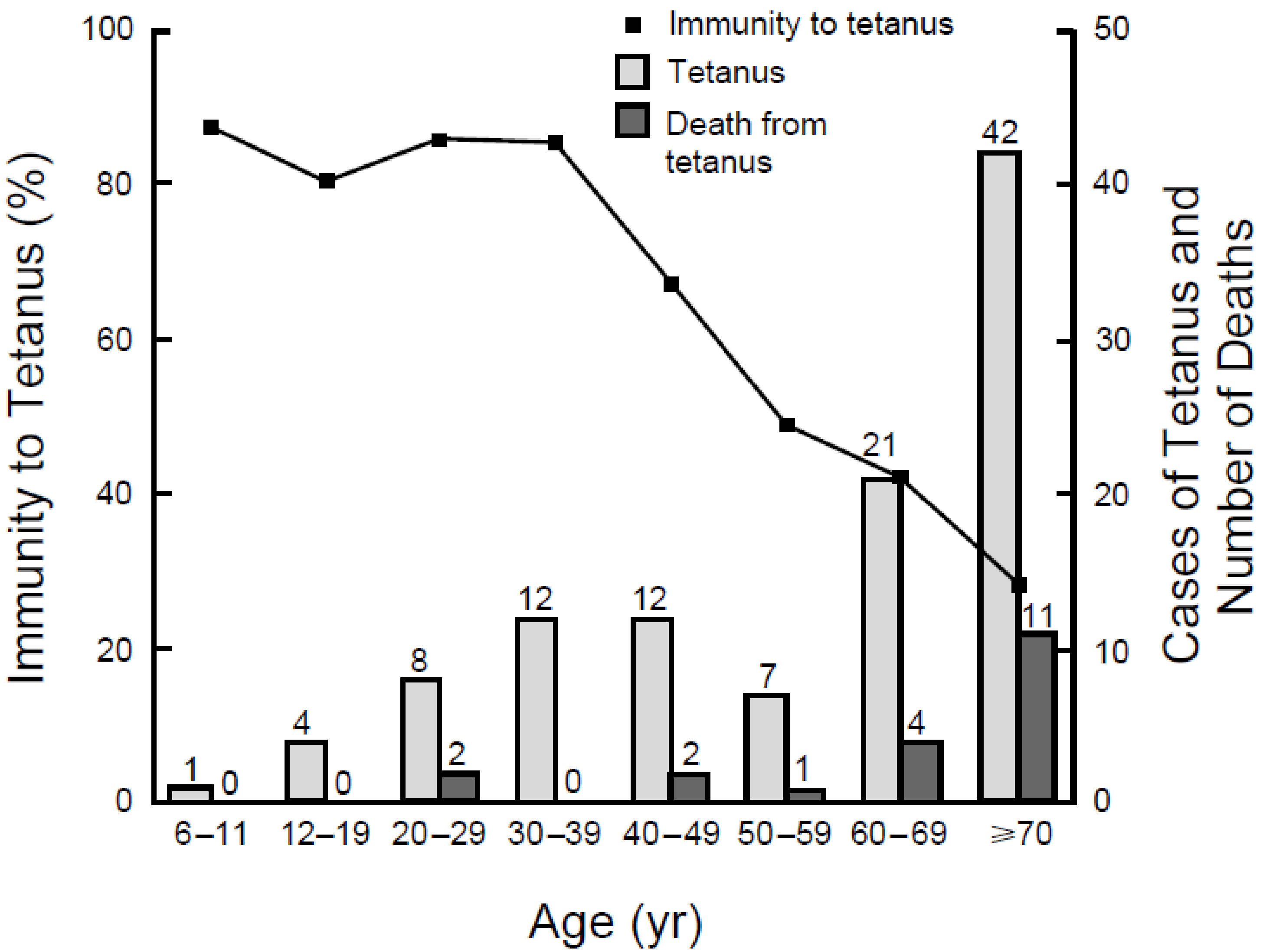


Figure 3. Age-Specific Prevalence of Immunity to Tetanus, Cases of Tetanus, and Deaths from Tetanus in the United States, 1989 to 1990.

[Human Vaccines 5:5, 341-346; May 2009]; ©2009 Landes Bioscience

Research Paper

Antibodies to tetanus, diphtheria and pertussis among healthy adults vaccinated according to the French vaccination recommendations

Odile Launay,[1-3] Christine Toneatti,[4] Claire Bernède,[4] Elisabeth Njamkepo,[5] Karine Petitprez,[2,3] Annie Leblond,[6] Sylvie Larnaudie,[7] Catherine Goujon,[8] Marie-Noelle Ungeheuer,[8] Faïza Ajana,[9] Christian Raccurt,[10] Jean Beytout,[11] Christian Chidiac,[12] Damien Bouhour,[13] Didier Guillemot[4,14,15] and Nicole Guiso[5,*]

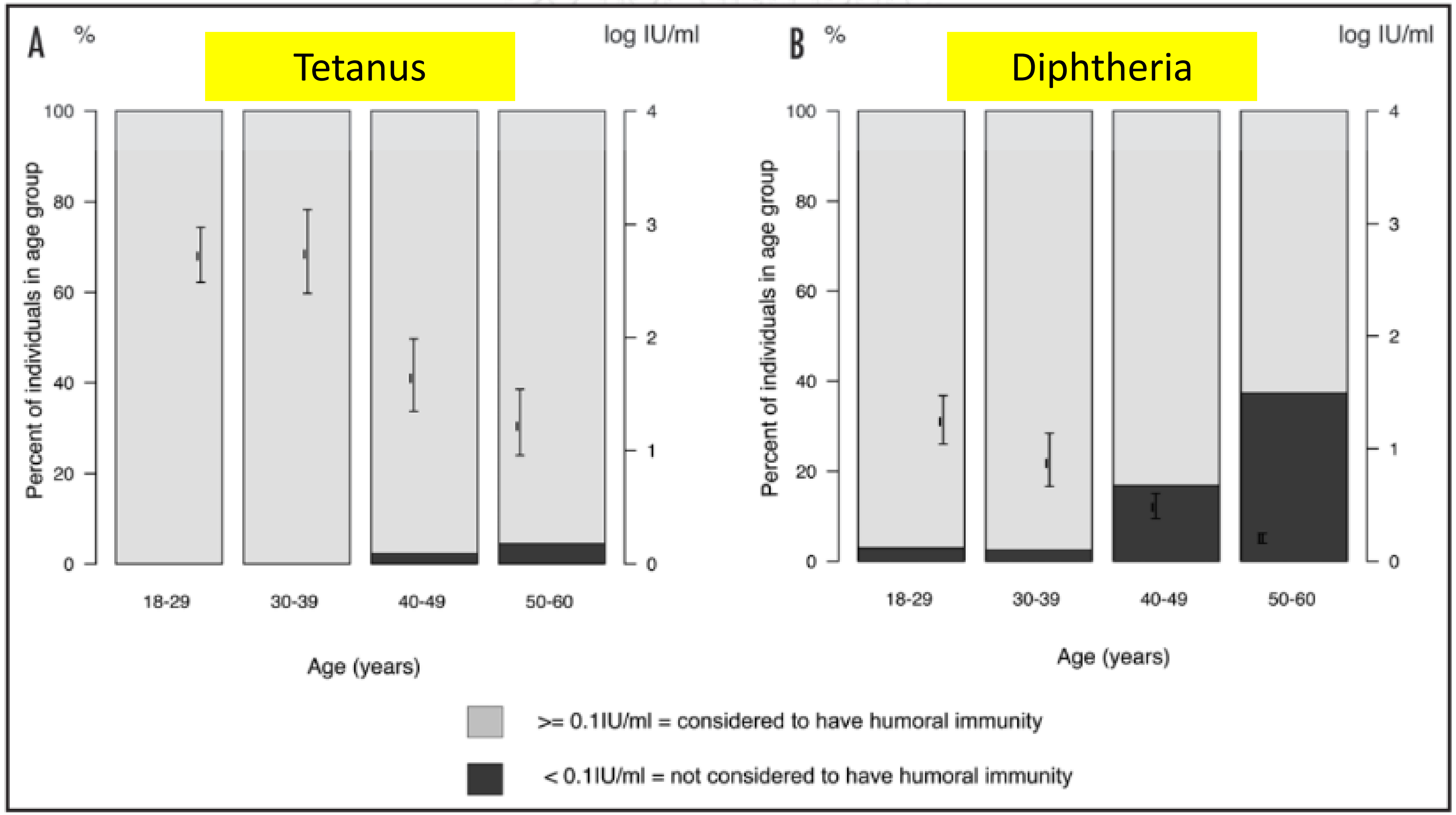


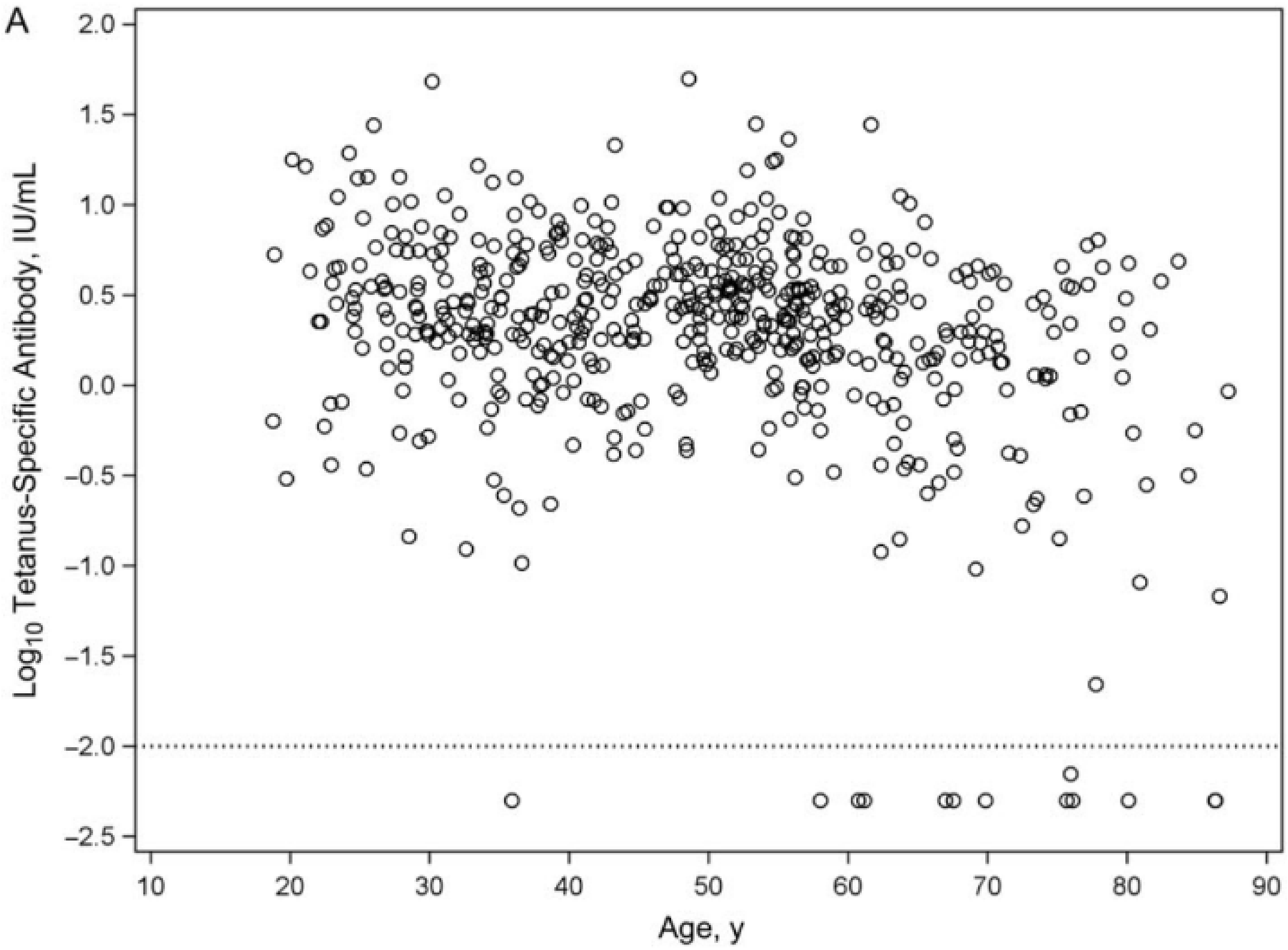
Figure 1. Concentrations of antibodies to diphtheria and tetanus toxoids. (A) Concentrations and geometric mean concentrations of anti-TT antibodies, including 95% confidence intervals, by age group. (B) Concentrations and geometric mean concentrations of anti-DT antibodies, including 95% confidence intervals, by age group.

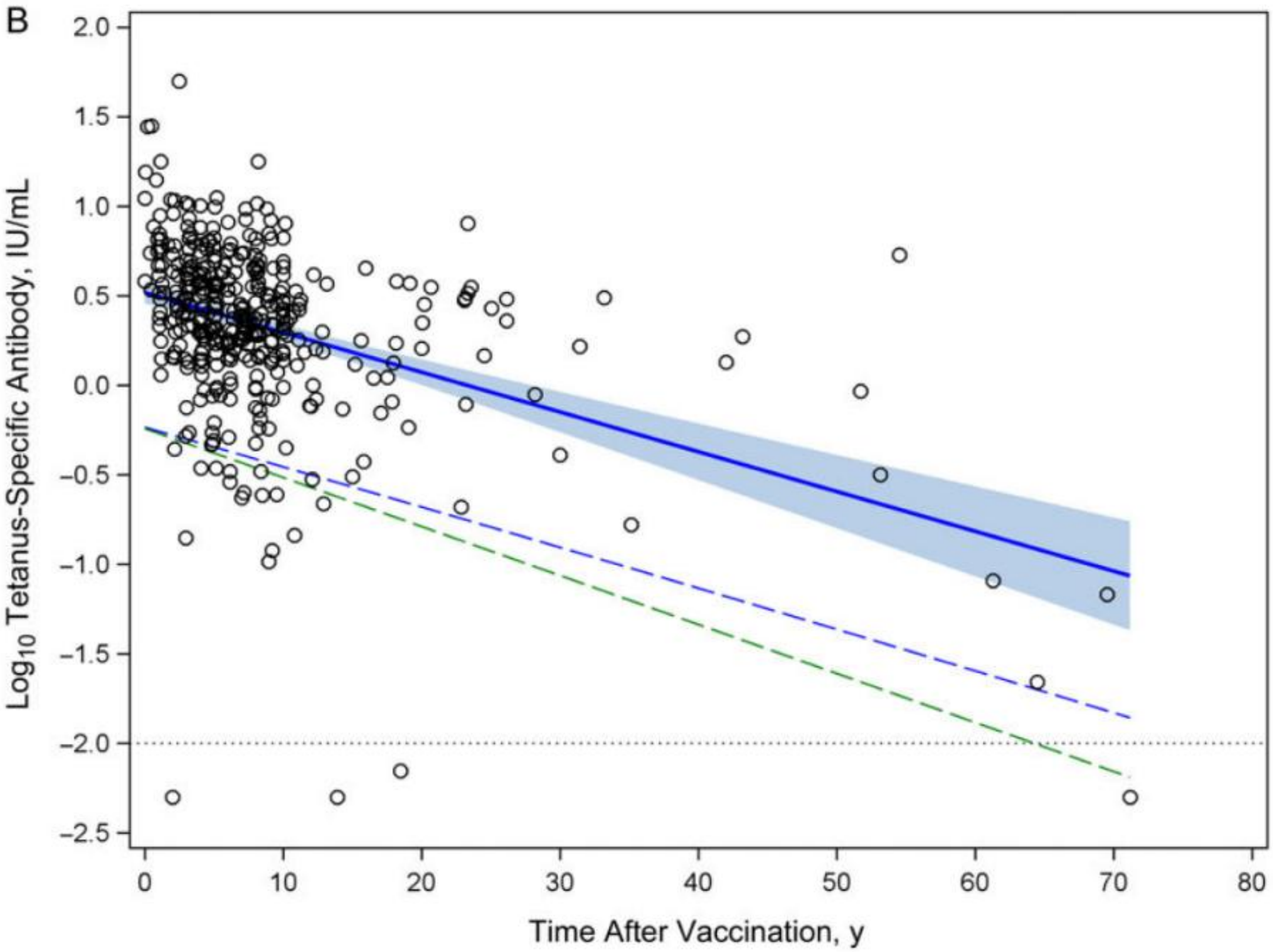
Durability of Vaccine-Induced Immunity Against Tetanus and Diphtheria Toxins: A Cross-sectional Analysis

Erika Hammarlund,[1] Archana Thomas,[1] Elizabeth A. Poore,[2] Ian J. Amanna,[2] Abby E. Rynko,[1] Motomi Mori,[3,4] Zunqiu Chen,[4] and Mark K. Slifka[1]

[1]Division of Neuroscience, Oregon National Primate Research Center, Department of Molecular Microbiology and Immunology, Oregon Health & Science University, [2]Najít Technologies, Beaverton, [3]Biostatistics Shared Resource, Knight Cancer Institute, and [4]Division of Biostatistics, Department of Public Health & Preventive Medicine, Oregon Health & Science University, Portland

La décroissance des anticorps contre le tétanos dans les différentes classes d'âge est lente mais perceptible




B
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
Log10 Tetanus-Specific Antibody, IU/mL
0
10
20
30
40
50
60
70
80
Time After Vaccination, y

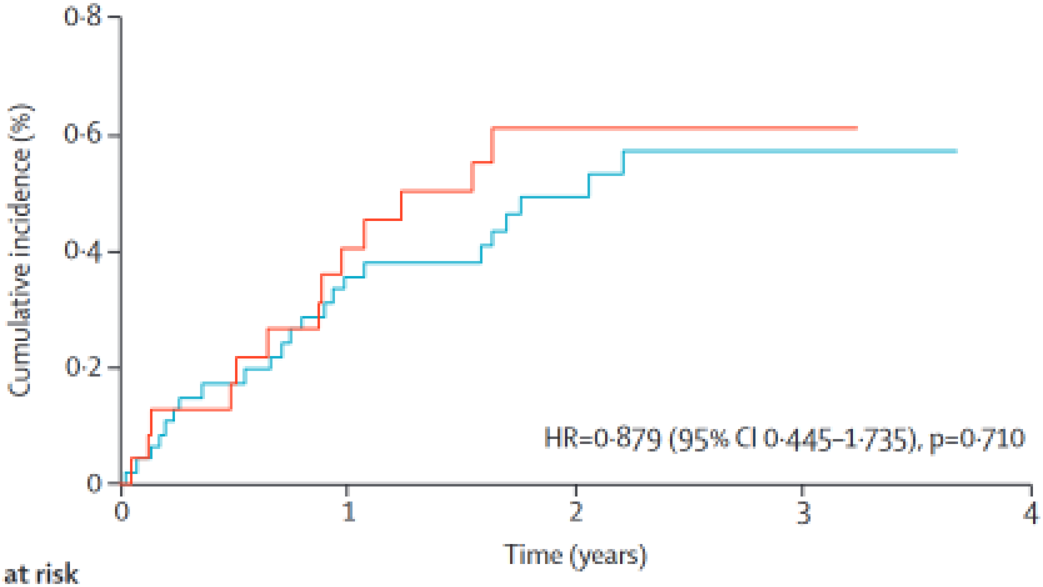
Autres vaccins

2021

Safety, immunogenicity, and efficacy of a *Clostridioides difficile* toxoid vaccine candidate: a phase 3 multicentre, observer-blind, randomised, controlled trial

Guy de Bruyn, David L Gordon, Theodore Steiner, Paul Tambyah, Catherine Cosgrove, Mark Martens, Ehab Bassily, Eng-Soon Chan, Dhaval Patel, Josh Chen, Julian Torre-Cisneros, Carlos Fernando De Magalhães Francesconi, Richard Gesser, Robert Jeanfreau, Odile Launay, Thelma Laot, Rayo Morfin-Otero, Ernesto Oviedo-Orta, Yoon Soo Park, Franco M Piazza, Christine Rehm, Enrique Rivas, Steve Self, Sanjay Gurunathan*

B **Per protocol analysis**



	0	1	2	3	4
Number at risk					
C difficile toxoid vaccine candidate	4786	4248	2832	884	..
Placebo	2378	2104	1391	451	..
Number of events					
C difficilee toxoid vaccine candidate	0	16	21	23	..
Placebo	0	9	13	13	..

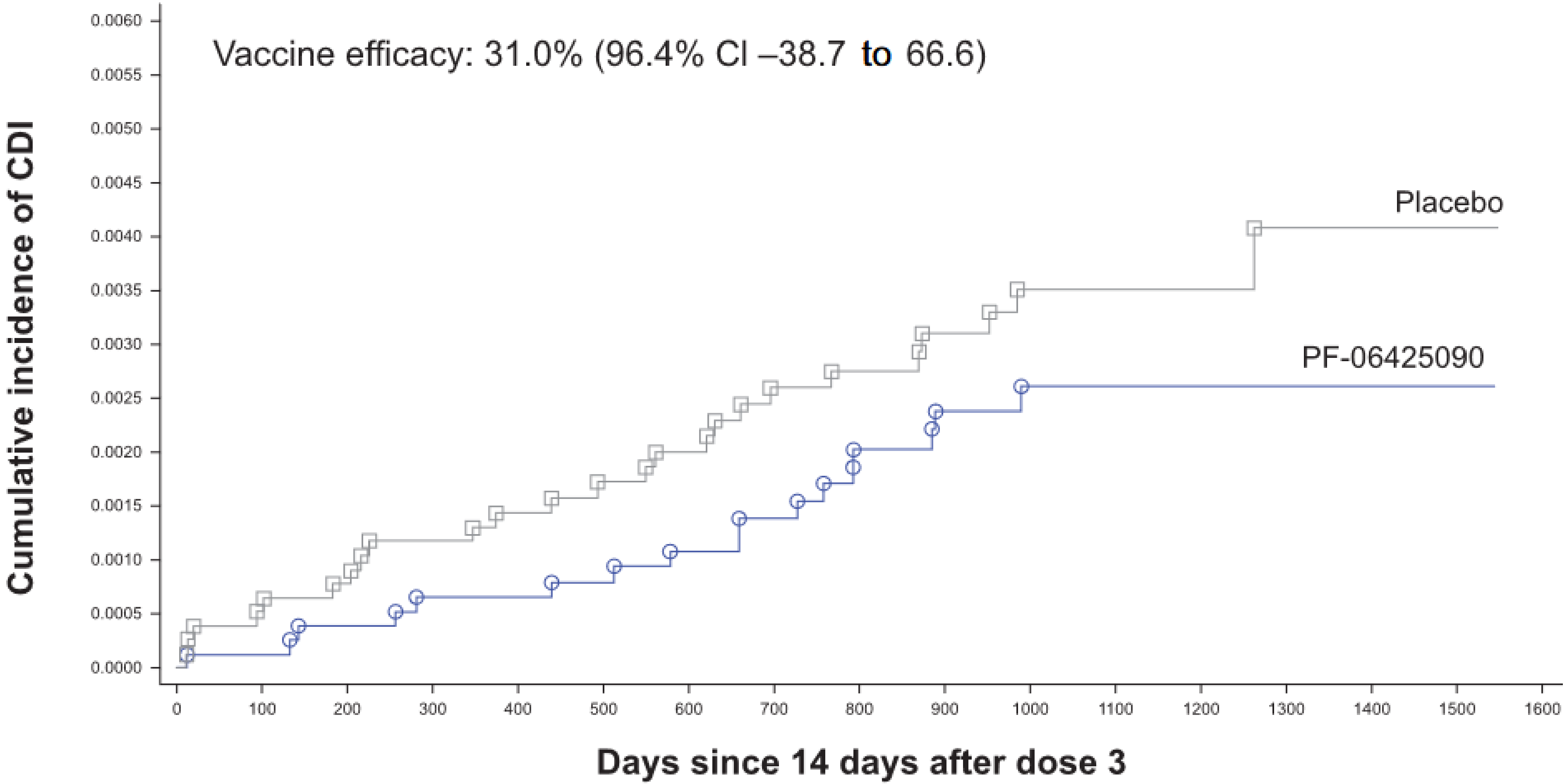
2024

Clinical Infectious Diseases

MAJOR ARTICLE

CLOVER (CLOstridium difficile Vaccine Efficacy tRial) Study: A Phase 3, Randomized Trial Investigating the Efficacy and Safety of a Detoxified Toxin A/B Vaccine in Adults 50 Years and Older at Increased Risk of *Clostridioides difficile* Infection

Curtis J. Donskey,[1] Erik R. Dubberke,[2] Nicola P. Klein,[3] Elizabeth G. Liles,[4] Katarzyna Szymkowiak,[5] Mark H. Wilcox,[6] Jody Lawrence,[7] Salim Bouguermouh,[8] Haiying Zhang,[7] Kenneth Koury,[8] Ruth Bailey,[9] Helen M. Smith,[9] Stephen Lockhart,[9] Erik Lamberth,[7] Warren V. Kalina,[8] Michael W. Pride,[8] Chris Webber,[9] Annaliesa S. Anderson,[8] Kathrin U. Jansen,[8] William C. Gruber,[8] and Nicholas Kitchin[9]; on behalf of the CLOVER (CLOstridium difficile Vaccine Efficacy tRial) Study Group



Number of participants at risk for CDI																	
PF-06425090	7707	7628	7495	7370	7203	7017	6776	6492	6186	5368	4321	3361	2301	1410	548	60	0
Placebo	7805	7724	7586	7462	7302	7103	6882	6582	6277	5465	4435	3407	2358	1416	549	69	0
Confirmed CDI																	
PF-06425090	0	1	3	5	5	6	8	10	14	16	17	17	17	17	17	17	17
Placebo	0	4	6	9	11	13	15	19	20	22	24	24	24	25	25	25	25

Pourquoi ces échecs des vaccins anti-*C. diff* ?

- Parce que les vaccins ne suscitent pas d'IgA anti-toxine ?

- Parce que les personnes ont une mauvaise réponse vaccinale ?
  - Immunosenescence
  - immunodépression

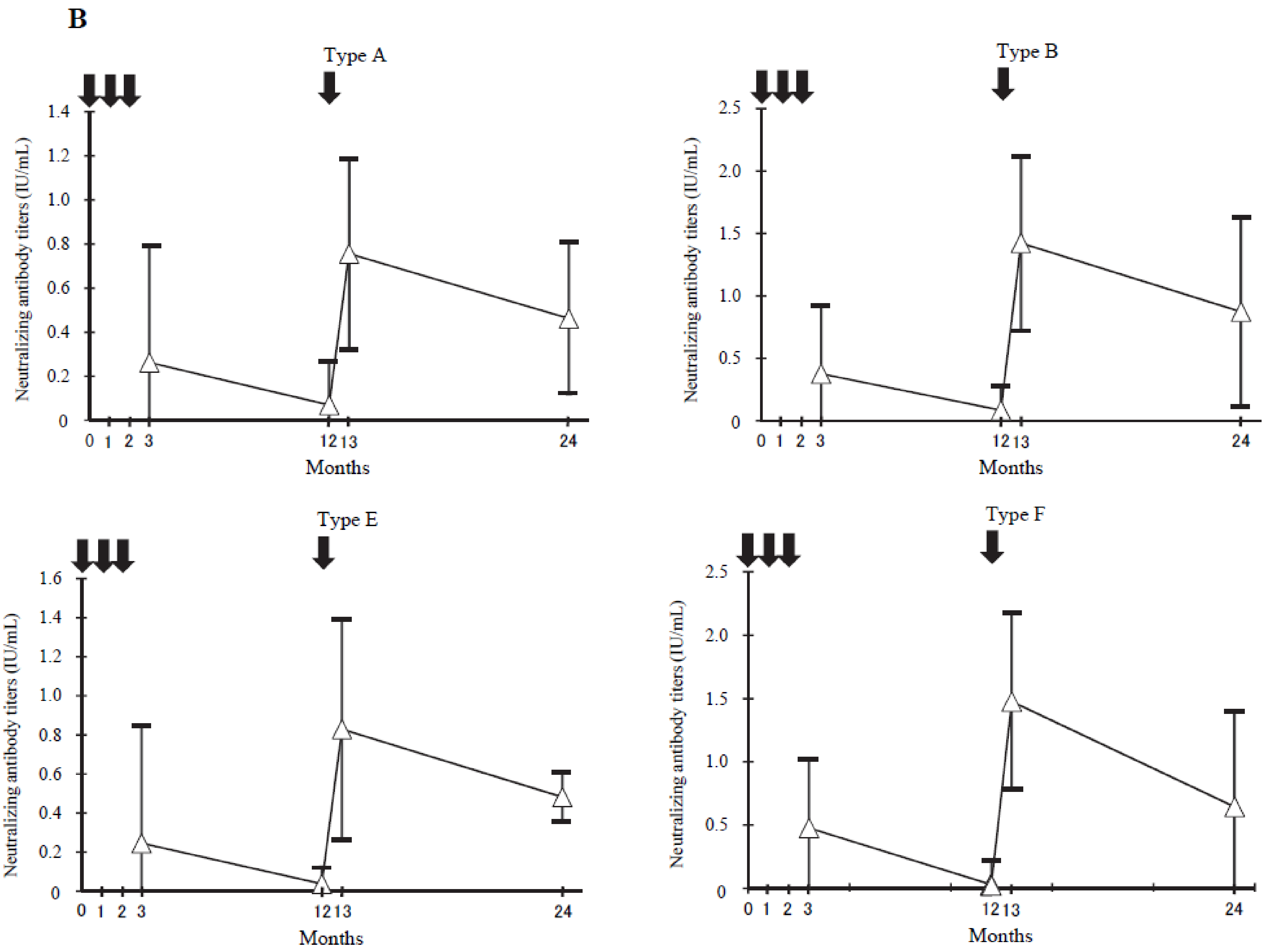
- Parce qu'il y n'y a pas que les toxines dans la vie ?
  - Dysbiose persistante
  - Colonisation persistante

Jpn. J. Infect. Dis., 70, 423–429, 2017

Original Article

Clinical Study of New Tetravalent (Type A, B, E, and F) Botulinum Toxoid Vaccine Derived from M Toxin in Japan

Yasushi Torii[1,2,3*], Nakaba Sugimoto[2], Tomoko Kohda[4], Shunji Kozaki[4], Kazunori Morokuma[3], Yoshikane Horikawa[3], Akihiro Ginnaga[3], Akihiko Yamamoto[5], and Motohide Takahashi[6]



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Transcutaneous immunization with the heat-labile toxin (LT) of enterotoxigenic *Escherichia coli* (ETEC): Protective efficacy in a double-blind, placebo-controlled challenge study☆

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Table 1

Output of loose stools and treatment with antibiotics and IV fluids for 22 vaccinees and 15 controls with moderate to severe ETEC illness

	Vaccinees		Placebo recipients		*p*-value
	Value	Range	Value	Range	
Mean no. of loose stools	6.8	2–15	9.7	3–39	0.04[a]
Mean total weight of loose stools	840	389–2033	1147	506–4508	<0.05[a]
No. of subjects who received early antibiotics	16/22 (73%)		12/15 (80%)		0.07[c]
Mean time to antibiotics	63	30–120	51	21–120	0.04[b]
No. of subjects who received IV fluids	3/22 (14%)		6/15 (40%)		0.03[c]
Mean time to receipt of IV fluids	36	25–48	29	20–47	<0.05[d]

[a] Statistical tests used: longitudinal analysis.

[b] Statistical tests used: Wilcoxon Rank sum.

[c] Statistical tests used: Chi-Square.

[d] Statistical tests used: Kurskell–Wallis.

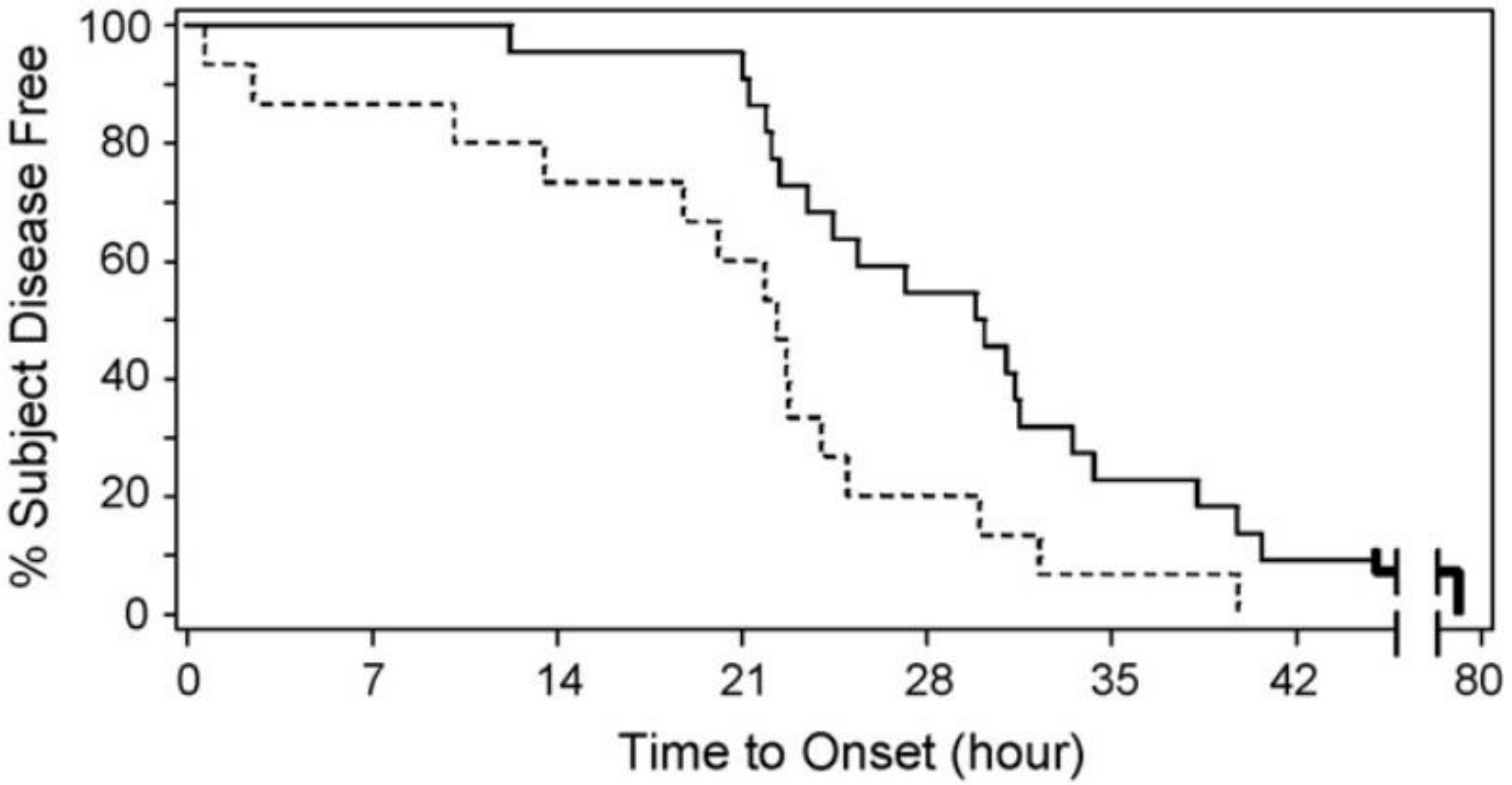

Fig. 3. Time to onset of diarrheal disease. The time to onset of diarrhea is shown for 22 vaccinees (solid line) and 15 placebo-recipients (dashed line) who met the definition of moderate to severe ETEC illness ($p = 0.001$). No new onset of ETEC illness was seen after 80 h.