Anticipating (re)emerging infections to ensure blood safety

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Conflict of interest disclosure: none, other than being employed by the French transfusion public service (Etablissement Français du Sang)
(Re)emerging infectious diseases

(Re)emerging infectious diseases

Figure 1. Major Emerging and Reemerging Infectious-Disease Outbreaks, Epidemics, and Pandemics, 2002 through 2015.

The Neglected Dimension of Global Security — A Framework for Countering Infectious-Disease Crises

Peter Sands, M.P.A., Carmen Mundaca-Shah, M.D., Dr.P.H., and Victor J. Dzau, M.D.
A traveled world

April 1935 map showing Imperial Airways' routes from the UK to Australia and South Africa
A traveled world
A warmer world

End of the 20th century (A) and projected (2011–2040) (B) climatic suitability of *Aedes albopictus* in Europe, with locations of important harbours
A world with changing human interventions

Maps showing the geographical distribution of *Aedes aegypti* (presence shown in red) at different times in the Americas.

- 1930
- 1954
- 1998
Mapping global environmental suitability for Zika virus

Jane P Messina, Moritz UG Kraemer, Oliver J Brady, David M Pigott, Freya M Shearer, Daniel J Weiss, Nick Golding, Corrine W Ruktanonchai, Peter W Gething, Emily Cohn, John S Brownstein, Kamran Khan, Andrew J Tatem, Thomas Jaenisch, Christopher JL Murray, Fatima Marinho, Thomas W Scott, Simon I Hay

University of Oxford, United Kingdom; University of Melbourne, United Kingdom; University of Southampton, United Kingdom; Harvard Medical School, United Kingdom; Harvard Medical School, United States; University of Toronto, Canada; Heidelberg University Hospital, Germany; University of Washington, Seattle, United States; Ministry of Health Brazil, Brazil; University of California Davis, United States
WHO boss: Zika result of 'massive' mosquito control failures

By Euan McKirdy, CNN
Updated 0652 GMT (1452 HKT) May 24, 2016

Global environmental suitability

Poritz UG, Kraemer, Oliver J Brady, David M Pew, Daniel J Weiss, Nick Golding, Corrine W W Gething, Emily Cohn, John S Brownstein, John T Tatem, Thomas Jaenisch, Christopher JL Althofer, Thomas W Scott, Simon I Hay

Kingdom; University of Melbourne, United Kingdom; University of Cambridge, United Kingdom; Harvard Medical School, United Kingdom; Harvard School of Public Health, United States; University of Toronto, Canada; Heidelberg University, Germany; University of Washington, Seattle, United States; Ministry of Health, Brazil; Brazil; University of California Davis, United States
Fears rise over yellow fever’s next move

Scientists warn vaccine stocks would be overwhelmed in the event of large urban outbreaks.

WHERE MIGHT YELLOW FEVER GO NEXT?

An ongoing outbreak of yellow fever in Angola has scientists worried that the virus might spread to cities that harbour its urban carrier, the *Aedes aegypti* mosquito.
A poorly known world

Hepatitis E: The ‘New Kid on the Block’ or an Old Friend?

Harry R. Dalton

Fig. 1. Most cases of zoonotic, locally acquired, hepatitis E in developed countries are asymptomatic. Only a small minority has clinically evident hepatitis. The grey areas represent emerging clinical phenotypes of HEV infection, including a range of neurological syndromes.

Source and route of HEV infection (Kamar et al, Lancet 2012)
No Artifact, Hepatitis E Is Emerging
Zaaijer HL, Hepatology, 2015

An ever changing world

Hogema et al
Transfusion, 2014 and 2016

Fig. 2. Percentage of HEV RNA-positive donations in 2013 and 2014. Points show the percentage of positive donations detected each time the screening was performed, approximately once every 4 weeks. Linear regression is indicated by the line.
An ever changing world

No Artifact, Hepatitis E Is Emerging
Zaaier HL, Hepatology, 2015

Hogema et al
Transfusion, 2014 and 2016

Fig. 2. Anti-HEV IgG seroprevalence among donors aged 18 to 21 in 1988, 1995, 2000, and 2011. The total number of samples and the number of anti-HEV–positive samples are indicated for each time point. The numbers above the bars denote the two-sided p values calculated using the chi-square method.
Etablissement Français du Sang: The french transfusion public service

15 Regional Blood Banks.
• 12 in metropolitan France.
• 3 in overseas territories (Guadeloupe-French Guiana, Martinique, Island of la Reunion-Mayotte)
Headquarters in Paris (St Denis, Paris)

Blood products delivered in 2015:
• Red blood cell concentrates: 2 415 230
• Platelets concentrates: 304 381
  - Apheresis platelets concentrates: 130 509
  - Whole blood derived platelets: 173 872
• Plasma : 353 977
Preventing transfusion-transmitted infections

- Donor screening
- Deferral of individuals with identified risk factors (infectious symptoms, lifestyle, eating habits, traveling, both personal and partner-related)
- Skin preparation
- Use of sterile bags (and outer bags)
- Diversion of the initial blood draw
- Pathogen detection
- Pathogen reduction
- Post-donation information
Preventing transfusion-transmitted infections

Pathogen detection - 2016

- HIV, HBC, HBV serology and NAT
- HTLV1 and 2 serology
- Syphilis serology
- Chagas and Malaria serology for at risk donors
- CMV serology for a fraction of blood donations
- HEV NAT for a fraction of blood donations (plasma)
- ZIKA NAT for Martinique and Guadeloupe blood donations
Preventing transfusion-transmitted infections

Pathogen detection - 2016

- HIV, HBC, HBV serology and NAT
- HTLV1 and 2 serology
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- CMV serology for a fraction of blood donations
- HEV NAT for a fraction of blood donations (plasma)
- ZIKA NAT for Martinique and Guadeloupe blood donations

Production of pathogen-reduced blood products - 2016

- Intercept® platelets (8% of transfused platelets): Alsace, Reunion Island, Martinique, Guadeloupe
- Intercept® plasma (20% of transfused plasma: pooled whole blood-derived plasma, apheresis plasma)
Recent EFS responses to (re) emerging diseases occurring in France

- Hepatitis E virus
- Chikungunya:
  - Martinique, Guadeloupe and French Guiana, 2014
- Zika virus
  - Martinique, Guadeloupe and French Guiana since January 2016

EFS responses to (re) emerging diseases occurring outside France:

- Differing travelers from affected regions
- Participating to the EbolaTx study: plasma from Ebola convalescent donors to Ebola patients in Conakry, Guinea (Van Griesven et al, NEJM, 2016)
Occurrence of transfusion-transmitted hepatitis E in France

Background

• Hepatitis E virus (HEV) infection in France is mainly a **zoonotic disease** and is **usually an acute self-limiting disease**

• However, HEV may cause **chronic hepatitis** with rapidly progressive cirrhosis in **organ transplant** recipients and patients with hematological malignancy, as well as a **fulminant hepatitis** in patients with **chronic liver disease**.

• Hepatitis E virus has been recognized since 2004 as a **transfusion transmissible infectious agent**

• Frequency of RNA HEV positive blood donations in France: **1 out of 2000** in 2013 (Gallian et al, EID, 2014). More recent data suggests a higher frequency (close to **1/1000 donations**)
Transfusion-transmitted hepatitis E in France

- 21 cases of HEV-TT reported between 2006 and 2015, most since 2012.

- Viral phylogenetic analysis established **transfusion imputability**.
- All cases are **genotype 3** (mainly 3f) except for 1 (genotype 4)
- **All type of blood products are involved:**
  - red blood concentrates (n=5)
  - platelet concentrates (n=9), including pooled whole blood-derived (n=5 + 1 Intercept®) platelets and apheresis (n=3) platelets
  - plasma (n=7), including solvent-detergent (SD)-plasma (n=4), Intercept® plasma (n=2) and quarantine plasma (n=1)
- Patients, aged **5 to 88 years old**, kidney (n=5) or liver **transplants** (n=3) and **hemopathies** mainly
- All cases suspected by **biological liver abnormalities** (cholestasis or cytolysis), for 2 a result of investigation from another case
- **Spontaneous resolution in 12 patients**
- **Chronic hepatitis requiring ribavirine treatment in 9 patients**, all immunosuppressed, and among which 2 patients developing significant liver fibrosis.
Transfusion-transmitted hepatitis E in France

- **21 cases** of HEV-TT reported between 2006 and 2015, most since 2012.

  - How frequently is HEV transmitted by an HEV-containing blood product?
  - How protective is prior immunization? Are there genetically determined protective factors?
  - Do we know all about HEV infection?; how sure are we about « low-risk » patients?
  - How severe can be chronic HEV infection? Are all HEV chronic infection accessible to treatment?

- Patients, aged **5 to 88 years old**, kidney (n=5) or liver **transplants** (n=3) and **hemopathies** mainly

- All cases suspected by **biological liver abnormalities** (cholestasis or cytolysis), for 2 a result of investigation from another case

- **Spontaneous resolution in 12 patients**

- **Chronic hepatitis requiring ribavirine treatment in 9 patients**, all immunosuppressed, and among which 2 patients developing significant liver fibrosis.
Anti-HEV IgG and IgM prevalence in France
Risk factors for seropositivity

Mansuy et al Hepatology, 2016
HEV risk factors:
✓ increasing age (p<0.001)
✓ eating:
  - pork meat (p=0.03)
  - pork liver sausages (p<0.001)
  - game meat (p<0.01)
  - offal (p<0.001)
  - oysters (p=0.02).
HEV protective factor:
✓ drinking bottled water (p<0.02)
Transfusion-transmitted hepatitis E in France

• 21 cases of HEV-TT reported between 2006 and 2015, most since 2012.

HEV RNA testing
Real Star HEV RT PCR Altona (EUROBIO) : SD 95% = 23 UI/ml (WHO standard)

January 2013 to December 2014:
• SD-Plasma produced by the EFS (Bordeaux), 70 liter pool, 100 apheresis plasma donations

Since January 2015:
• A fraction (30%) of plasma (quarantine or Intercept) intended for high-risk patients:
  ✓ Organ and allogeneic HSC transplantation recipients
  ✓ Other severely immunosuppressed patients
  ✓ Patients with chronic liver disease

2016: Expanding HEV testing for at least a fraction of all blood products is being considered
Figure 2. Origin, Spread, and Distribution of Chikungunya Virus and Its Vectors.

The map shows the African origins of enzootic chikungunya virus strains and the patterns of emergence and spread of the Asian lineage and Indian Ocean lineage (IOL) of the virus during epidemics since the 1950s, based on phylogenetic studies. The distributions of the peridomestic vectors, *Aedes aegypti* and *A. albopictus*, are also shown. ECSA denotes eastern, central, and southern African.
Chikungunya epidemic in the Caribbean in 2014

- Risk prevention measures included:
  - detection of CHIKV RNA (individual NAT in dedicated arboviral laboratory in Marseille)
  - 3-day quarantine combined with reinforced post-donation information
  - use of Intercept platelets

- Individual NAT screening of 16269 donations identified 63 CHIKV positive donations (0.4%, with 1 to 2% at the epidemic peak) for which related blood products were discarded except for platelets transfused before NAT results.
- A large majority of donors reported symptoms within 3 days after donation
- Intercept platelets from CHIKV positive donations were transfused to 10 recipients with no clinical evidence for transmission.
At peak of the epidemic (June 2014), the estimated ratio between CHIKV positive blood donors and reported CHIKV clinical cases was of 1/1000.
A critical issue: vector competence
- No autochthonous CHIKV cases in mainland France resulting from travelers returning from the Caribbean during the epidemic
- However, autochthonous CHIKV cases from a traveler returning from Cameroun
Zika Virus

Lyle R. Petersen, M.D., M.P.H., Denise J. Jamieson, M.D., M.P.H., Ann M. Powers, Ph.D., and Margaret A. Honein, Ph.D., M.P.H.

Figure 1. Areas in Which Zika Virus Infections in Humans Have Been Noted in the Past Decade (as of March 2016).

Only sporadic infections have occurred in Southeast Asia, the Philippines, and Indonesia.
Zika Virus

Rapid Communications

Potential for Zika virus transmission through blood transfusion demonstrated during an outbreak in French Polynesia, November 2013 to February 2014

D Musso (dmusso@ilm.pl), T Nhan, E Robin, C Roche, D Bierlaire, K Zisou, A Shan Yan, V M Cao-Lormeau, J Broult

1. Unit of Emerging Infectious Diseases, Institut Louis Malardé, Tahiti, French Polynesia
2. Centre hospitalier de Taaoa, Tahiti, French Polynesia

Figure 1. Areas in Which Zika Virus Infections in Humans Have Been Noted in the Past Decade (as of March 2016). Only sporadic infections have occurred in Southeast Asia, the Philippines, and Indonesia.
ZIKA virus outbreak in the America

TTI preventive measures in Martinique, Guadeloupe and French Guiana

Epidemic state since late January (Martinique, French Guiana) and April 2016 (Guadeloupe)

**Pre-existing measures :**

- 3-day quarantine & enhanced post-donation information request
- Intercept® treatment for platelets
- Plasma for transfusion provided from mainland France

**Specific measures:**

- Since Jan 4th 2016, RBC (and plasma) transfusion of pregnant women by blood products collected in mainland France
- Since Feb 15th 2016, implementation of an individual NAT ZIKV screening (dedicated arbovirus laboratory, Marseille)
ZIKA ID-NAT screening

Semi automated individual NAT Screening platform (RealStar® Zika Virus RT-PCR Kit) in a dedicated laboratory in Marseille. Estimated analytical sensitivity: LOD90% = 140 copies/mL (*with reference to the European Virus Archive Zika standard#1 (strain H/PF/2013)

Percentage of RNA ZIKV positive in blood donations collected in Martinique
ZIKA ID-NAT screening

Semi automated individual NAT Screening platform (RealStar® Zika Virus RT-PCR Kit) in a dedicated laboratory in Marseille. Estimated analytical sensitivity: LOD90% = 140 copies/mL (*with reference to the European Virus Archive Zika standard#1 (strain H/PF/2013)

Between Jan 19 and Apr 18-2016: 4,406 donations tested

➔ 46 donations ZIKV RNA positive

- Martinique: 42 / 2,642 donations (1.59%) positive
- Guadeloupe: 4 / 1,764 donations (0.23%) positive
Zika virus disease epidemic: potential association with microcephaly and Guillain–Barré syndrome

Fifth update, 11 April 2016
**Table 1. Time of detection and Zika virus RNA load in samples of infected individuals**

<table>
<thead>
<tr>
<th>Sample origin</th>
<th>Time of detection (days)</th>
<th>Viral RNA load</th>
<th>Isolation of replicative particles</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before the onset of symptoms</td>
<td>After the onset of symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood</td>
<td>2-3</td>
<td>11</td>
<td>up to $8.1 \times 10^6$ copies/mL</td>
<td>+</td>
</tr>
<tr>
<td>Urine</td>
<td>-</td>
<td>10 to 20</td>
<td>$0.7 - 220 \times 10^6$ copies/mL</td>
<td>+</td>
</tr>
<tr>
<td>Saliva</td>
<td>-</td>
<td>2 to 8</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Seminal fluid</td>
<td>-</td>
<td>21 to 62</td>
<td>$1.1 - 2.9 \times 10^6$ copies/mL</td>
<td>+</td>
</tr>
<tr>
<td>Breast milk</td>
<td>-</td>
<td>3 to 8 after delivery</td>
<td>up to $2.1 \times 10^6$ copies/mL</td>
<td>+</td>
</tr>
</tbody>
</table>
**EU (ECDC) recommendation:** donors who have had a sexual contact with a man who travelled or lived in a Zika-affected during the 3 (to 6) months prior to the sexual contact may only give blood after at least 28 days after the last sexual contact.

Recommendation implemented in mainland France (and Réunion island) since May 15th

**Risk assessment** (Santé Publique – France):

- Blood donation by a Zika positive donor resulting from a sexual transmission in mainland France: $1/0.49 \times 10^6$ to $1/11.6 \times 10^6$ (6/year to 1/4 years)
- Transfusing such a blood product to a pregnant women: 1/90 to 1/2100 years
Anticipating (re)emerging infections to ensure blood safety

• Assessing the risk of transfusion-mediated disease transmission
Anticipating (re)emerging infections to ensure blood safety

- Assessing the risk of transfusion-mediated disease transmission

**Transmission of West Nile Virus from an Organ Donor to Four Transplant Recipients**

Martha Iwarnoto, M.D., M.P.H., Daniel B. Jernigan, M.D., M.P.H.,
Antonio Guasch, M.D., Mary Jo Trepka, M.D., M.S.P.H.,
Carina G. Blackmore, D.V.M., Ph.D., Walter C. Hellinger, M.D.,
Si M. Pham, M.D., Sherif Zaki, M.D., Ph.D., Robert S. Lanciotti, Ph.D.,
Susan E. Lance-Parker, D.V.M., Ph.D., Carlos A. DiazGranados, M.D.,
Andrea G. Winquist, M.D., Carl A. Perlino, M.D., Steven Wiersma, M.D., M.P.H.,
Krista L. Hillyer, M.D., Jesse L. Goodman, M.D., M.P.H.,
Anthony A. Marfin, M.D., M.P.H., Mary E. Chamberland, M.D., M.P.H.,
and Lyle R. Petersen, M.D., M.P.H.,
for the West Nile Virus in Transplant Recipients Investigation Team*
Anticipating (re)emerging infections to ensure blood safety

Transmission of West Nile Virus through Blood Transfusion in the United States in 2002

Lisa N. Pealer, Ph.D., Anthony A. Marfin, M.D., M.P.H.,
Lyle R. Petersen, M.D., M.P.H., Robert S. Lanciotti, Ph.D., Peter L. Page, M.D.,
Susan L. Stramer, Ph.D., Mary Grace Stobierski, D.V.M., M.P.H.,
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Anticipating (re)emerging infections to ensure blood safety

Transmission of West Nile Virus through Blood Transfusion

West Nile Virus among Blood Donors in the United States, 2003 and 2004

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Assessing the chikungunya transfusion risk

Despite presence of CHIKV virus in the blood of infected asymptomatic blood donors and animal models suggesting that intravenous inoculation is able to transmit infection, there has been no reported case of transfusion-transmitted CHIKV disease word-wide yet.

- Insufficient investigations?
- Difficulty to identify transfusion-transmitted CHIKV infections in a CHIKV epidemic setting?

- A viral load in pre/asymptomatic donors inauspicious to blood CHIKV transmission?
- A rapid appearance of IgM Ab in infected (asymptomatic) donors and/or a rapid increase in the % of CHIKV immunized transfusion recipients?
- Modulation of infectious virulence in relation with blood products manufacturing and storage?
- A less efficient direct blood transmission compared to an arthropod (saliva) -mediated transcutaneous transmission?
Anticipating (re)emerging infections to ensure blood safety

• Assessing the risk of transfusion-mediated disease transmission
Anticipating (re)emerging infections to ensure blood safety

- Assessing the risk of transfusion-mediated disease transmission

During a large epidemic of DENV-4 infection in Brazil:
- > 0.5% of donations were RNA positive
- 37.5% (95%CI, 15.2%-64.6%) of RNA positive blood donations transmitted the DENV-4 to the recipients
- **No significant differences in symptoms and mortality between cases and controls**
Anticipating (re)emerging infections to ensure blood safety

- Assessing the risk of transfusion-mediated disease transmission

Why has *Borrelia burgdorferi* not been transmitted by blood transfusion?

- Most spirochetemic patients are symptomatic
- Deferring individuals with recent tick bites, where implemented, may further eliminate a proportion of spirochetemic donors
- Spirochetemia is relatively short-lived
- Viable spirochetes present in whole blood may be as low as 1 spirochete/10 mL
- Host-adapted *B. burgdorferi* may not survive well under blood storage conditions
Anticipating (re)emerging infections to ensure blood safety

- Assessing the risk of transfusion-mediated disease transmission
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*TRANSFUSION* Volume 53, November 2013

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Identification of a novel pathogenic *Borrelia* species causing Lyme borreliosis with unusually high spirochaetaemia: a descriptive study

Anticipating (re)emerging infections to ensure blood safety

- Assessing the risk of transfusion-mediated disease transmission
- Deferring at risk donors
Anticipating (re)emerging infections to ensure blood safety

• Assessing the risk of transfusion-mediated disease transmission
• Deferring at risk donors
• Introducing a 2 to 3 day quarantine combined with enhanced post-donation information

Enhanced post donation information, combined with a 72 hours quarantine, can potentially reduce up to 75 % the risk of transfusing a CHIKV+ blood product.
Anticipating (re)emerging infections to ensure blood safety

• Assessing the risk of transfusion-mediated disease transmission
• Deferring at risk donors
• Introducing a 2 to 3 day quarantine combined with enhanced post-donation information
• Pathogen detection
Anticipating (re)emerging infections to ensure blood safety

- **Pathogen detection:**
  - Testing whole blood donation: 100% RBC, 90% plasma, and 60% platelets (in France)
  - Requires individual technologies for each pathogen
  - Varying sensitivity depending on technology and pool size
  - A window period during which detection is impossible
  - Costly
Anticipating (re)emerging infections to ensure blood safety

- Pathogen detection:
  - Testing whole blood donation: 100% RBC, 90% plasma and 60% platelets (in France)
  - Requires individual technologies for each pathogen
  - Varying sensitivity depending on technology and pool size
  - A window period during which detection is impossible

CDC Home
Centers for Disease Control and Prevention
CDC 24/7: Saving Lives. Protecting People.

Morbidity and Mortality Weekly Report (MMWR)
Fatal West Nile Virus Infection After Probable Transfusion-Associated Transmission — Colorado, 2012
Weekly
August 9, 2013 / 62(31);622-624
Anticipating (re)emerging infections to ensure blood safety

• Assessing the risk of transfusion-mediated disease transmission
• Deferring at risk donors
• Introducing a 2 to 3 day quarantine combined with enhanced post-donation information
• Pathogen detection
• Pathogen reduction
Anticipating (re)emerging infections to ensure blood safety

- Assessing the risk of transfusion-mediated disease

Pathogen reduction:
- Efficiently neutralizes a large variety of pathogens: known, emerging, remerging or unknown
- No window period
- “One for all” at risk situations (almost)
Anticipating (re)emerging infections to ensure blood safety

Hepatitis E transmission by transfusion of Intercept blood system–treated plasma

Lisette Hauser, Anne-Marie Roque-Afonso, Alexandre Beylouné, Marion Simonet, Bénédicte Deau Fischer, Nicolas Burin des Roziers, Vincent Mallet, Pierre Tiberghien and Philippe Bierling

Emerging/Re-emerging or unknown:

- No window period
- “One for all” at risk situations (almost)
Anticipating (re)emerging infections to ensure blood safety

Hepatitis E transmission by transfusion of Intercept blood system–treated plasma

Lisette Hauser, Anne-Marie Roque-Afonso, Alexandre Bevlouné, Marion Simonet, Bénédicte Deau, and Marc Faugère

Blood, 2014

Transmission of human immunodeficiency virus Type-1 by fresh-frozen plasma treated with methylene blue and light

Manuel Álvarez, Mar Luis-Hidalgo, María Alma Bracho, Amando Blanquer, Luis Larrea, José Villalba, Nieves Puig, Dolores Planelles, José Montoro, Fernando González-Candelas, and Roberto Roig

Transfusion, 2016
Anticipating (re)emerging infections to ensure blood safety

- Assessing the risk of transfusion-mediated disease transmission
- Deferring at risk donors
- Introducing a 2 to 3 day quarantine combined with enhanced post-donation information
- Pathogen detection
- Pathogen reduction
  - Efficiently neutralizes a large variety of pathogens: known, emerging, remerging or unknown
  - No window period
  - "One for all" at risk situations (almost)

Transmission of Plasmodium by whole blood treated with the Mirasol pathogen reduction technology system

Lancet, 2016

Jean-Pierre Allain, Alex K Owusu-Ofori, Sonny Michael Assennato, Susanne Marschner, Raymond P Goodrich, Shirley Owusu-Ofori

Transmission of Plasmodium by whole blood treated with the Mirasol pathogen reduction technology system

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Anticipating (re)emerging infections to ensure blood safety

**Pathogen reduction:**
- Efficiently neutralizes a large variety of pathogens: known, emerging, reemerging or unknown
- No window period
- One for all at risk situations (almost)

- Not (yet) available for RBC
- Induces qualitative and quantitative alterations
  - Lesser hemostatic efficacy of pathogen-reduced platelets?
  - Less hemostatic proteins in pathogen-reduced plasma
- Very costly
Anticipating (re)emerging infections to ensure blood safety

- Assessing the risk of transfusion-mediated disease transmission
- Deferring at risk donors
- Introducing a 2 to 3 day quarantine combined with enhanced post-donation information
- Pathogen detection
- Pathogen reduction
- Allocating available resources in due proportion of the health risk
ANTICIPATING EMERGING INFECTIOUS DISEASE EPIDEMICS

CURING and not HARMING: THAT IS THE QUESTION

CLINICAL PRACTICES & EMERGING DISEASES

SYSTEMIC VIEW: INFECTIOUS DISEASES IN HEALTH CARE FACILITIES

PATIENT-DOCTOR RELATIONSHIP IN AGE OF THE INTERNET

STRENGTHENING THE OVERALL HEALTH SYSTEM

DISCUSSION

Anticipating emerging infectious disease epidemics: an informal consultation
1-2 December 2015, Geneva
The ultimate anticipation for (re) emerging diseases?

Proof of principle for transfusion of *in vitro* generated red blood cells

Marie-Catherine Giarratana, Hélène Rouard, Agnès Dumont, Laurent Kiger, Innocent Safeukui, Pierre-Yves Le Pennec, Sabine François, Germain Trugnan, Thierry Peyrard, Tiffany Marie, Séverine Jolly, Nicolas Hebert, Christelle Mazurier, Nathalie Mario, Laurence Harmand, Hélène Lapillonne, Jean-Yves Devaux and Luc Douay
The ultimate anticipation for (re) emerging diseases?

Proof of principle for transfusion of in vitro generated red blood cells

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Anticipating (re)emerging infections to Ensure Blood Safety

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