

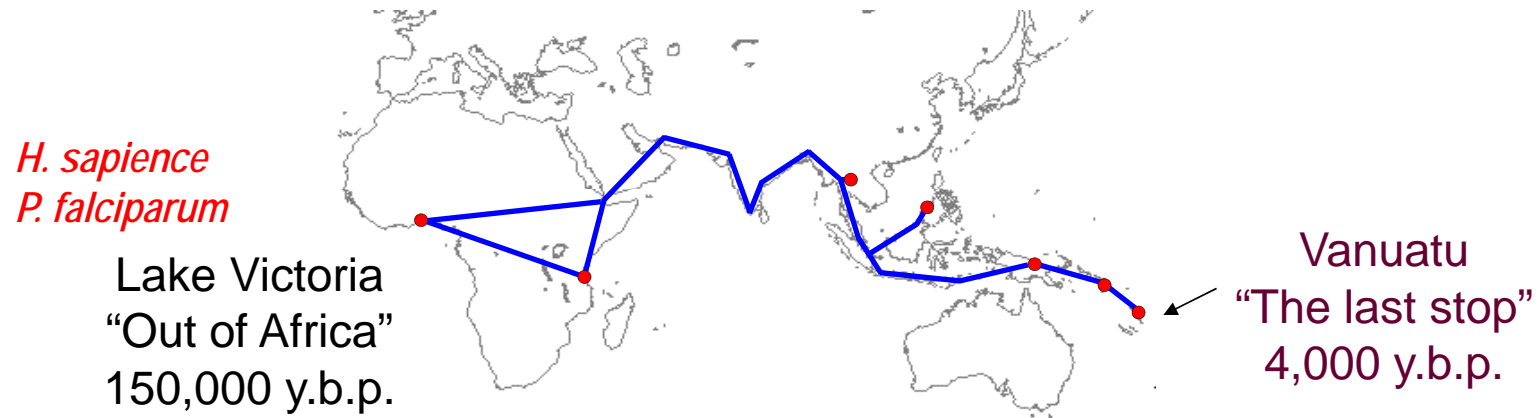
An aerial photograph of a tropical island, likely in Vanuatu, showing a large lagoon with a sandy beach and palm trees. The sky is blue with some clouds. The image is oriented vertically on the left side of the slide.

JITMM 2018, Bangkok

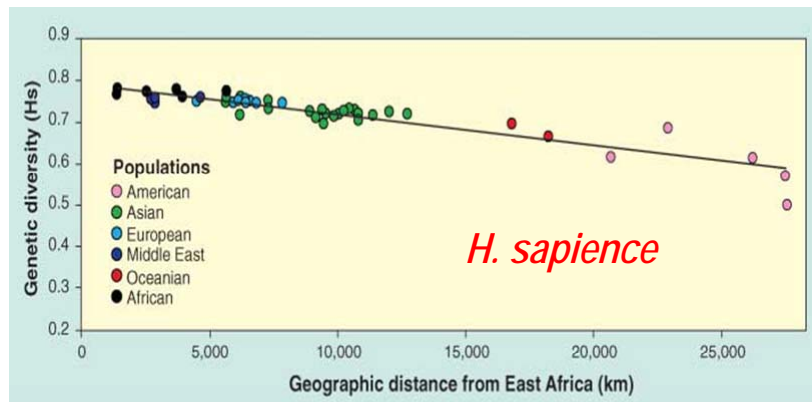
Combatting residual malaria
transmission on islands in
Vanuatu

Akira Kaneko
Karolinska Institutet
Osaka City University

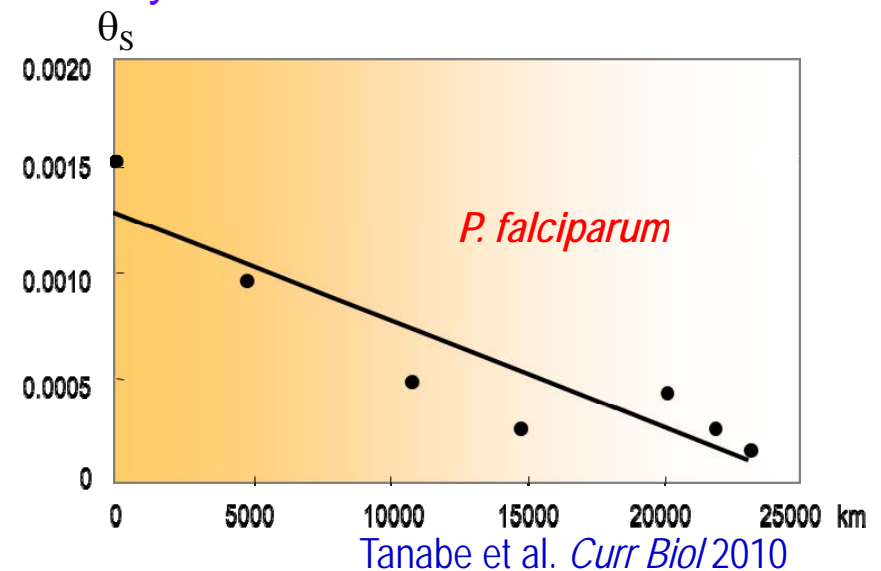
Co-evolutionary history of modern humans and malaria parasites



Negative correlation between genetic diversity and distance from east Africa



Lintz et al. *Nature* 2007

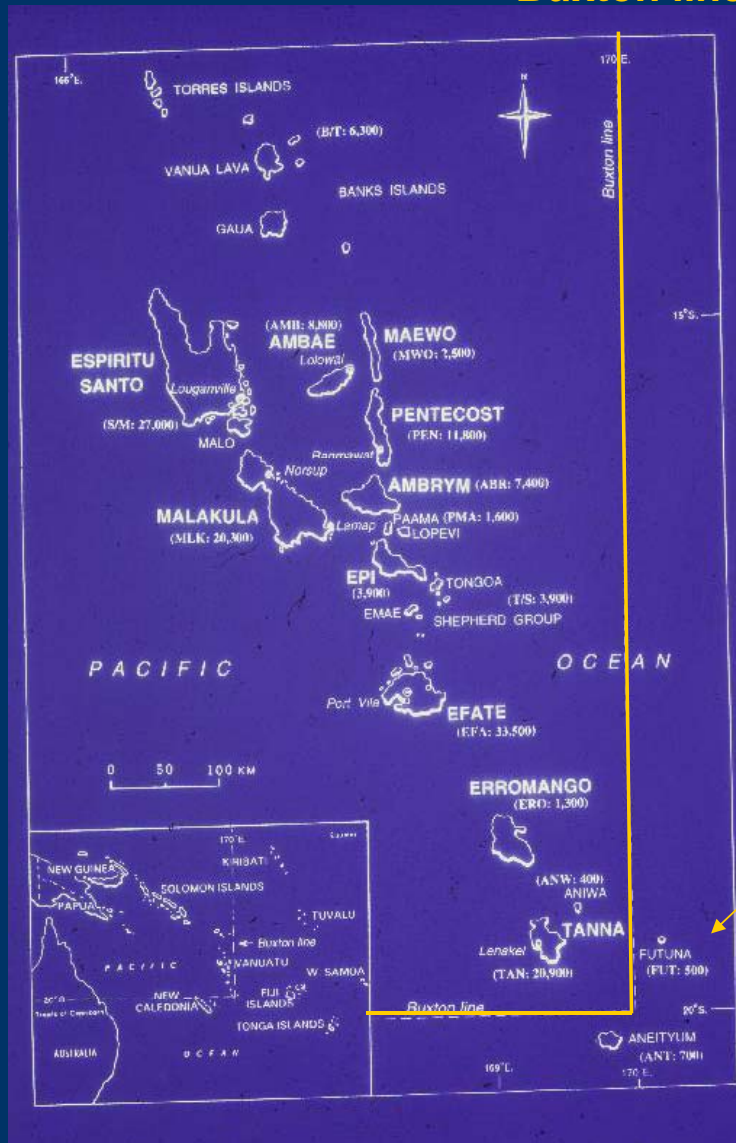


Tanabe et al. *Curr Biol* 2010

Buxton line The Vanuatu Archipelago

200,000 population
120 languages
68 inhabited islands

**Limit of Anopheles
mosquito and malaria in
the Southwest Pacific
(Buxton 1926)**





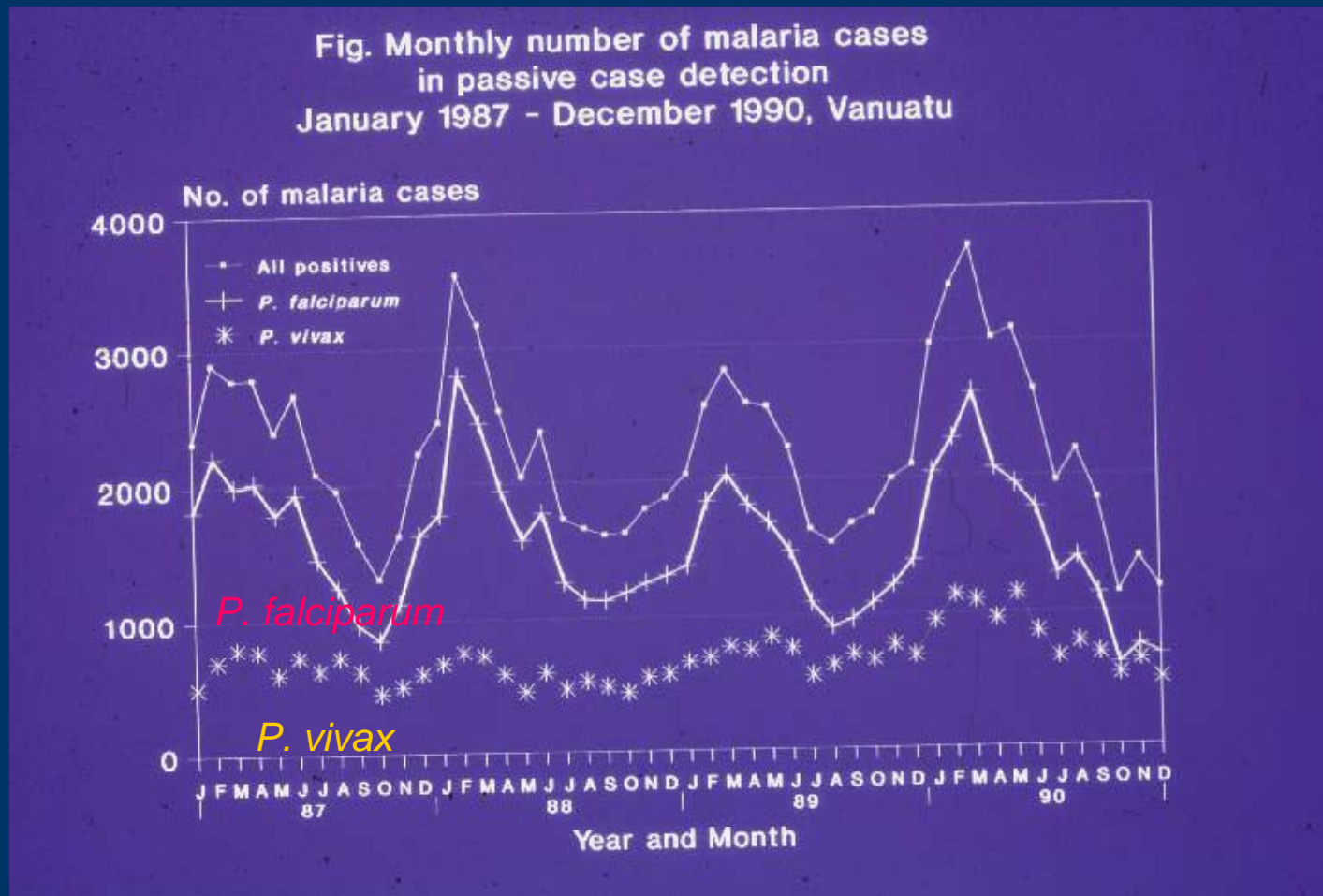








Seasonal fluctuations of malaria

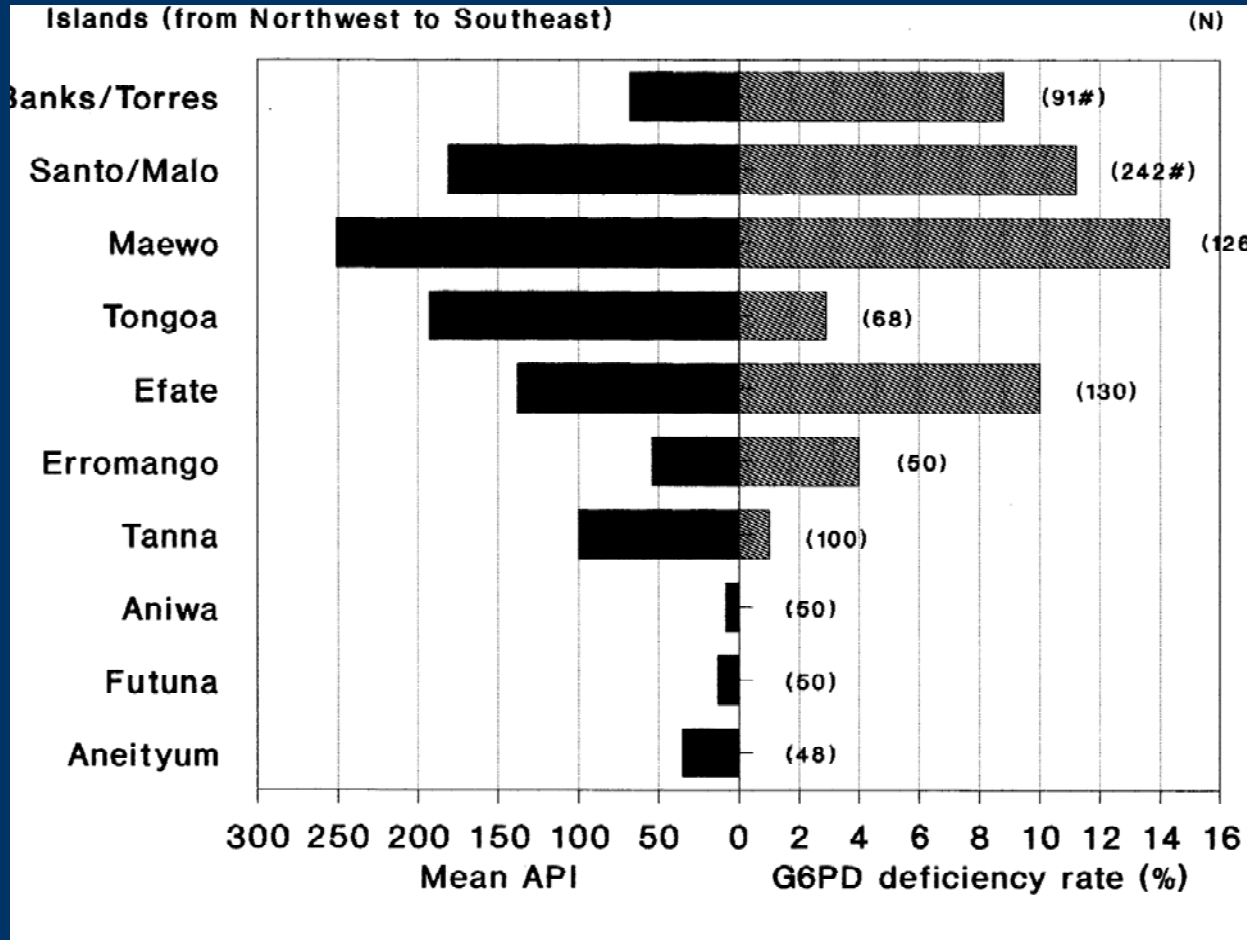


Passive Case Detection

(Kaneko A et al. 1998)

Malaria and G6PD deficiency on islands in Vanuatu

API: Annual parasite incidence per 1000 population



Northern islands
V
Southern islands

Supporting "Malaria hypothesis" (Kaneko A et al. 1998)



Malariometric surveys in communities on islands in Vanuatu, 1987-2018

The integrated community-directed malaria elimination strategy on Aneityum Island in 1991

=Short-term aggressive attack=





- Mass drug administration
- Impregnated bed nets

=Long-term sustainable strategy=

- Surveillance - *community microscopist*
- Re-impregnation of bed nets – *once a year*
- Larvivorous fish

MDA to cover the entire population on Aneityum just before the rainy season, Sep. –Nov., 1991

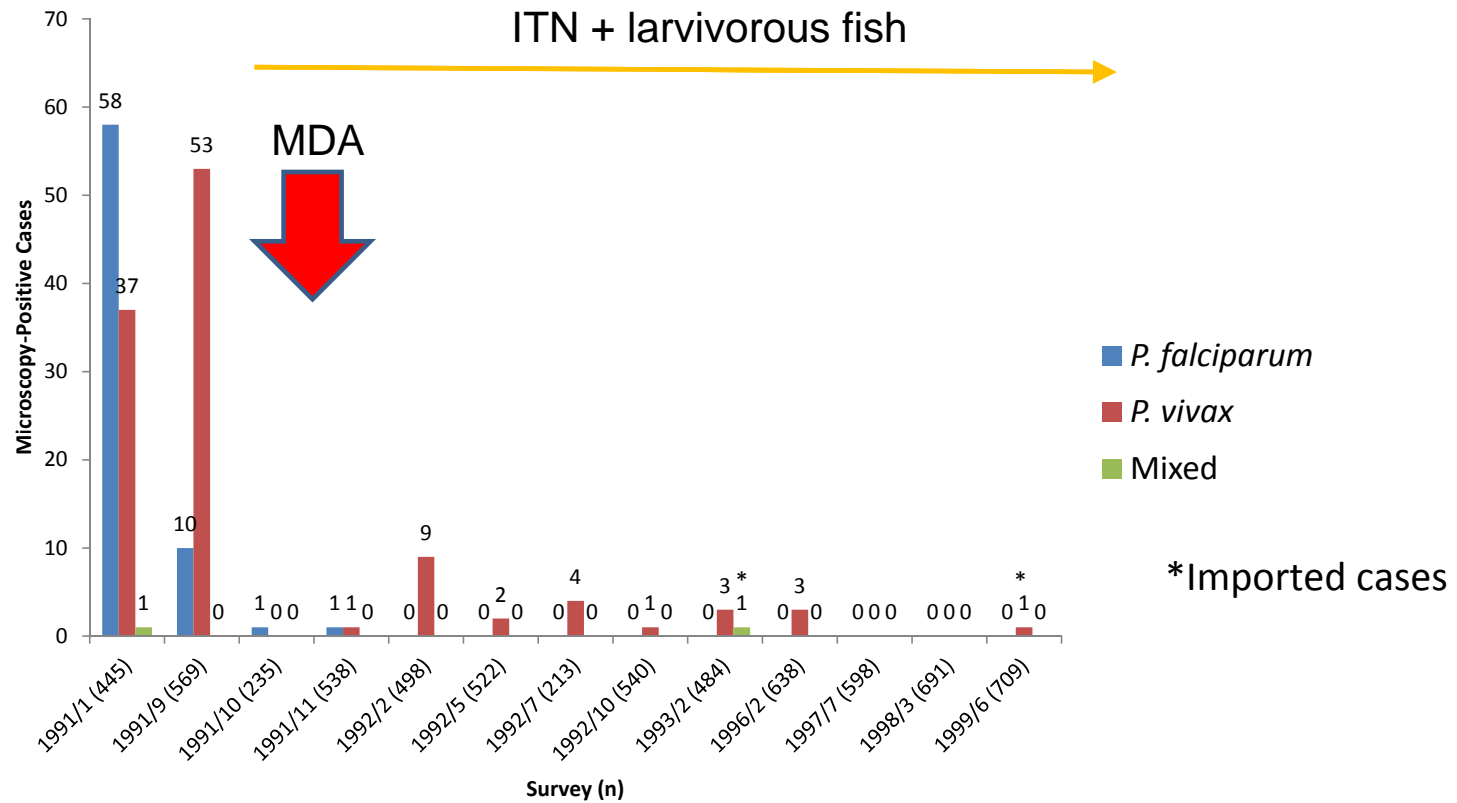
Week	Treatment (as adult dosage)			
1	primaquine 45mg	+	chloroquine 600mg	+ Fansidar 3 tab.*
2	primaquine 45mg	+	chloroquine 300mg	
3	primaquine 45mg	+	chloroquine 300mg	
4	primaquine 45mg	+	chloroquine 300mg	
5	primaquine 45mg	+	chloroquine 600mg	+ Fansidar 3 tab.
6	primaquine 45mg	+	chloroquine 300mg	
7	primaquine 45mg	+	chloroquine 300mg	
8	primaquine 45mg	+	chloroquine 300mg	
9	primaquine 45mg	+	chloroquine 600mg	+ Fansidar 3 tab.

	 	
Pf gametocytes Pv hypnozoites	The blood stages of Pf, Pv & Pm	Chloroquine- resistant Pf

Longevity of *An. farauti* < 5 weeks

- *To result in a malaria-free human & vector population on the island*

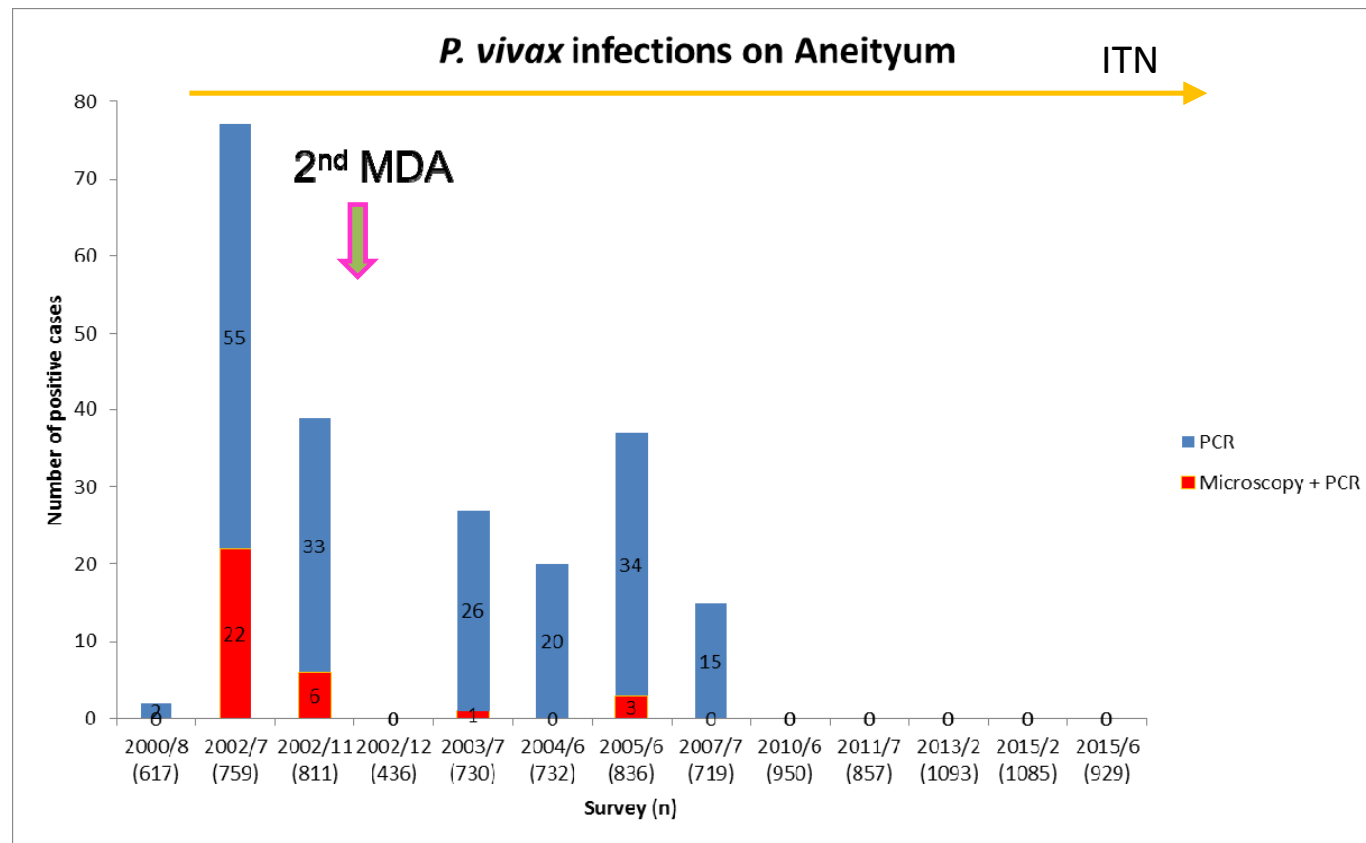
Annual cross sectional surveys on Aneityum, 1991-1999



(Kaneko A et al. 2000)

Malariometric Surveys (2000-2015)

No *P. falciparum* infection was detected except for a few imported cases .



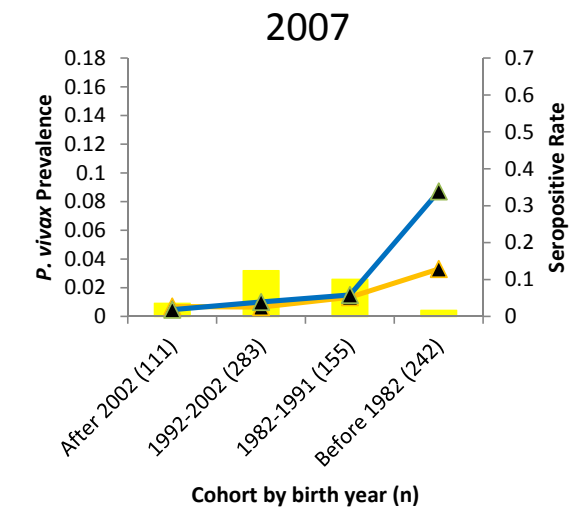
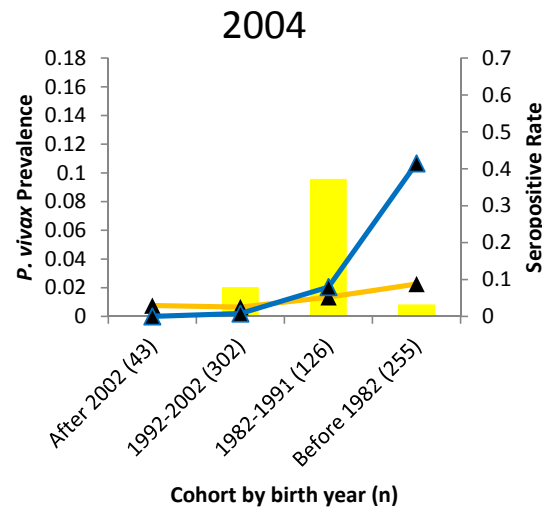
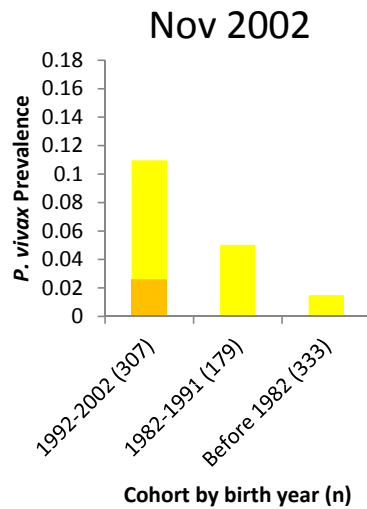
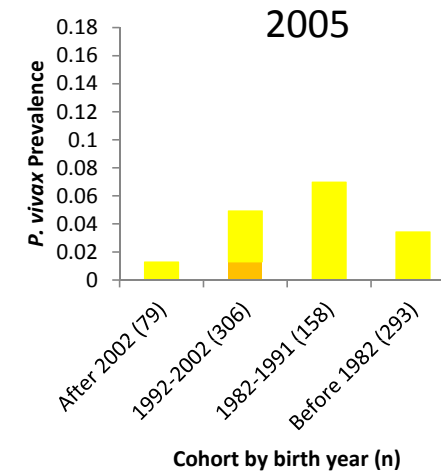
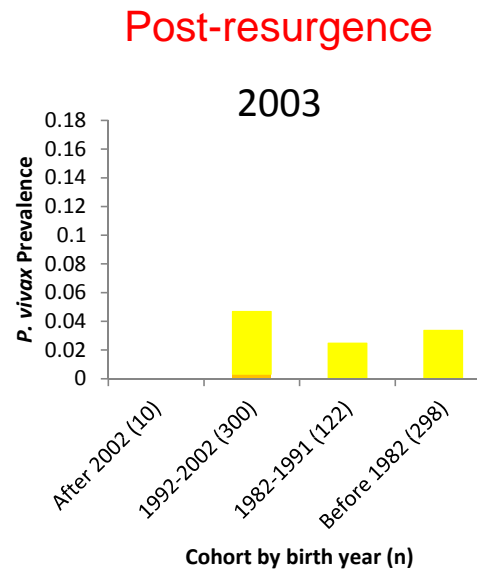
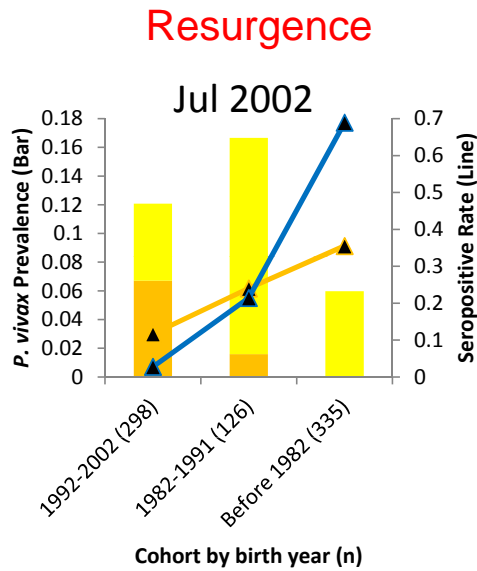
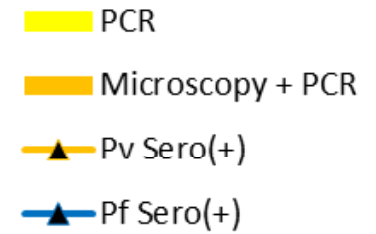
(Kaneko A, Unpublished)

The 2nd MDA on Aneityum island, November 2002

- to contain the *P. vivax* resurgence
- targeting the population <20 years old, based on the microscopy results
- with chloroquine and primaquine (daily 0.25 mg/kg for 14 days)
- with the high ITN provision (0.94 nets per person)

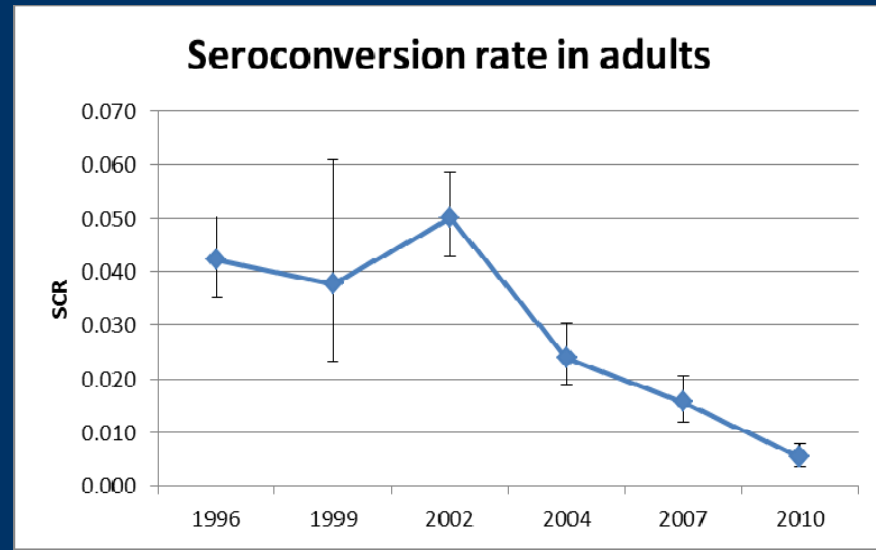
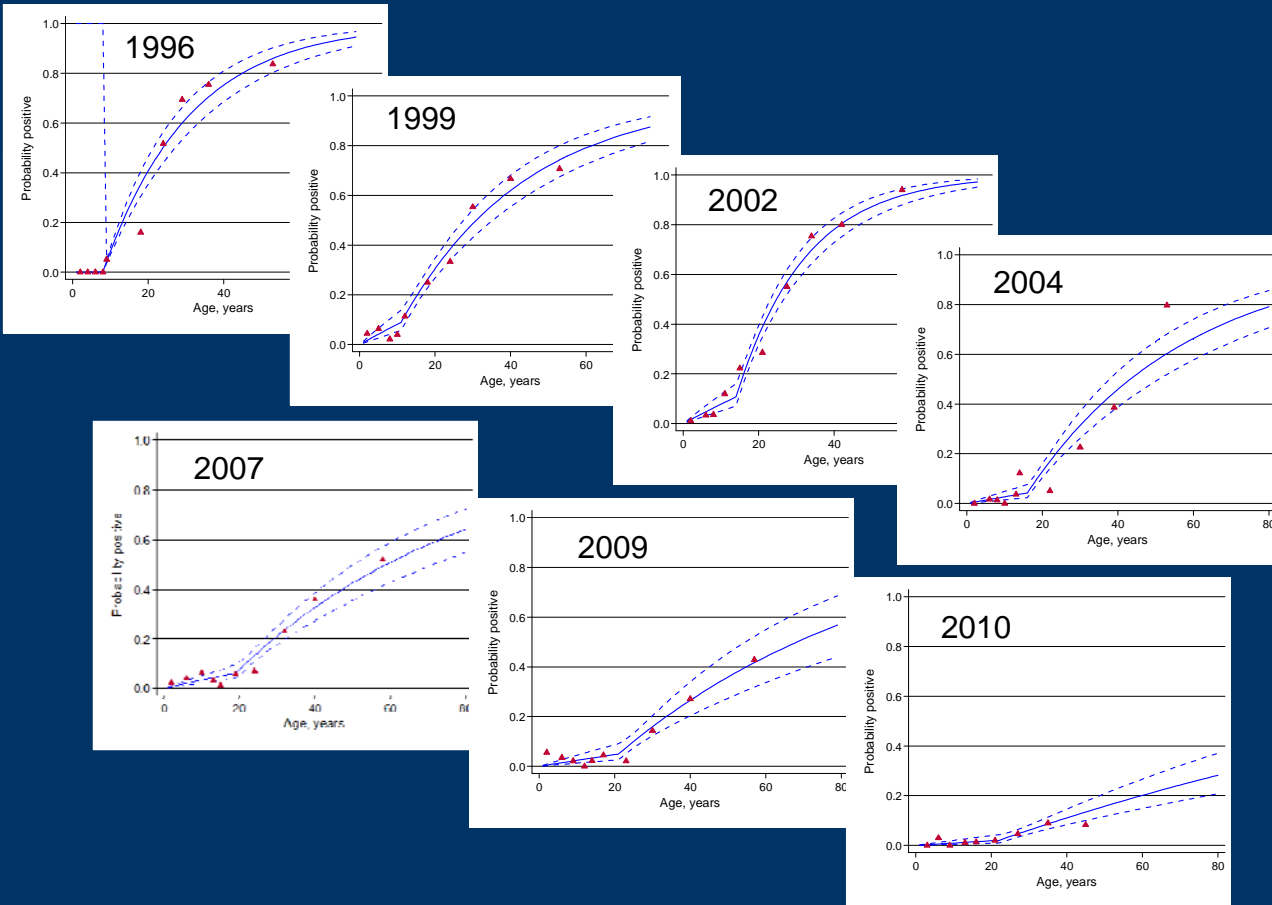


Age patterns of *P. vivax* prevalence on Aneityum

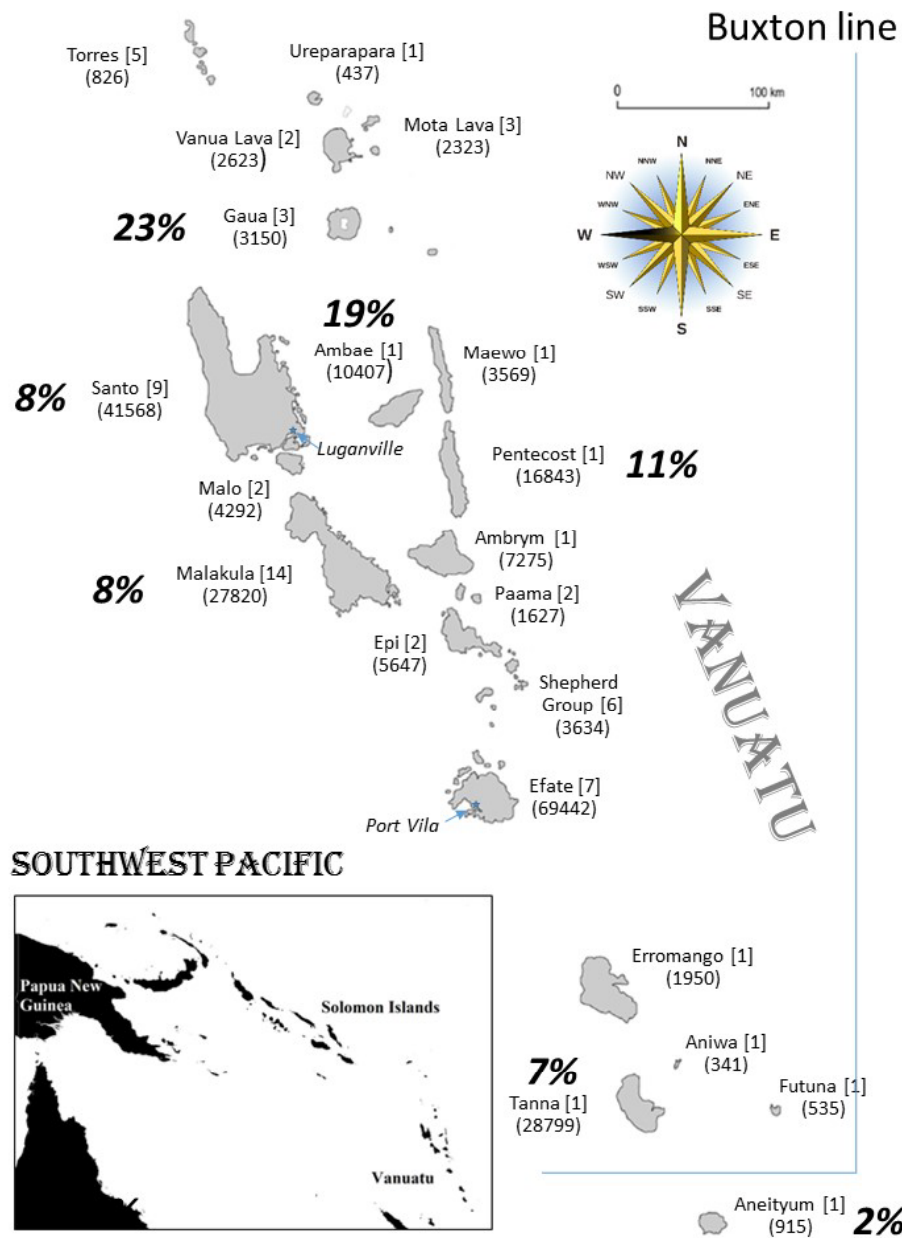


(Kaneko et al. 2014; unpublished)

Seroprevalence curves of IgG antibodies to *P. falciparum* schizont extracts on Aneityum, where malaria elimination was initiated in 1991



(Kaneko, Cook et al. unpublished)

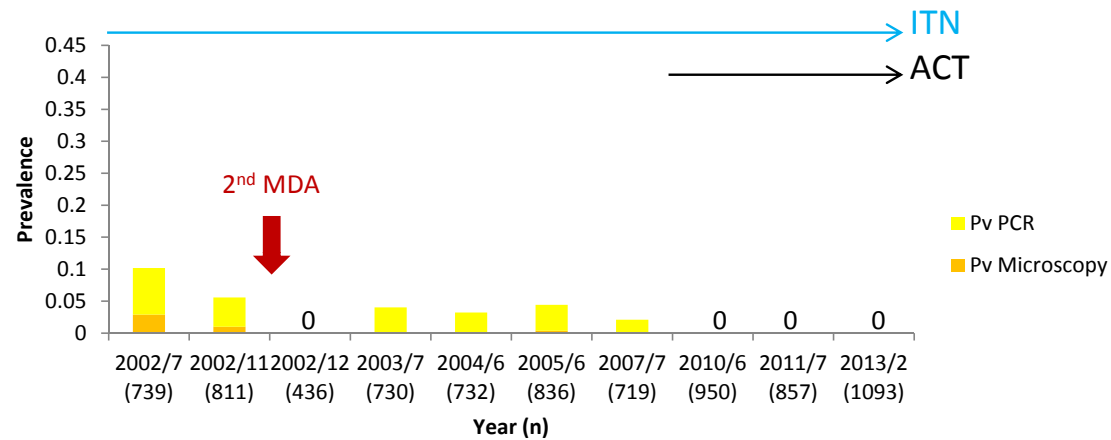


The Vanuatu Archipelago

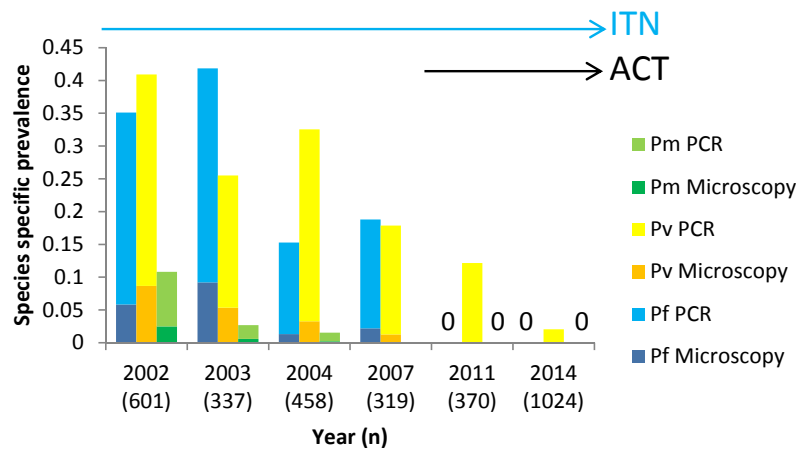
Parasite rates by microscopy around 2000

End malaria on islands in Vanuatu by 2025

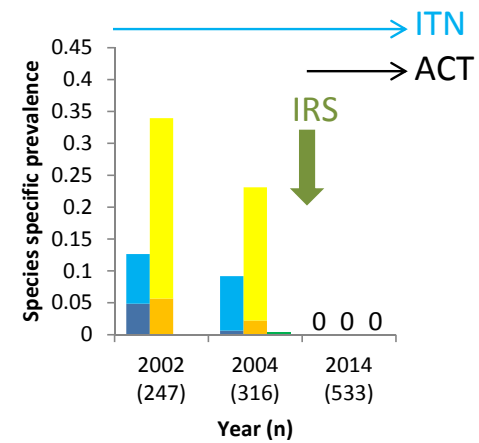
(Kaneko A, unpublished)



Aneityum



Ambae



Tanna

Malaria prevalence survey on islands in Vanuatu

	Prevalence by microscopy						API
	Islands	Examined	PR(%)	<i>P. falciparum</i>	<i>P. vivax</i>	<i>P. malariae</i>	
1988 to 1992	16	14476	11.9	5.2	6.7	0.1	180
1996 to 2002	16	16472	6.2	2.4	3.5	0.2	74
2011 to 2017	10	13879	0.6	0.4	0.2	0.0	13

Prevalence by PCR						
	Islands	Examined	PR(%)	<i>P. falciparum</i>	<i>P. vivax</i>	<i>P. malariae</i>
2011 to 2017	10	13121	2.6	0.1	2.5	0.0

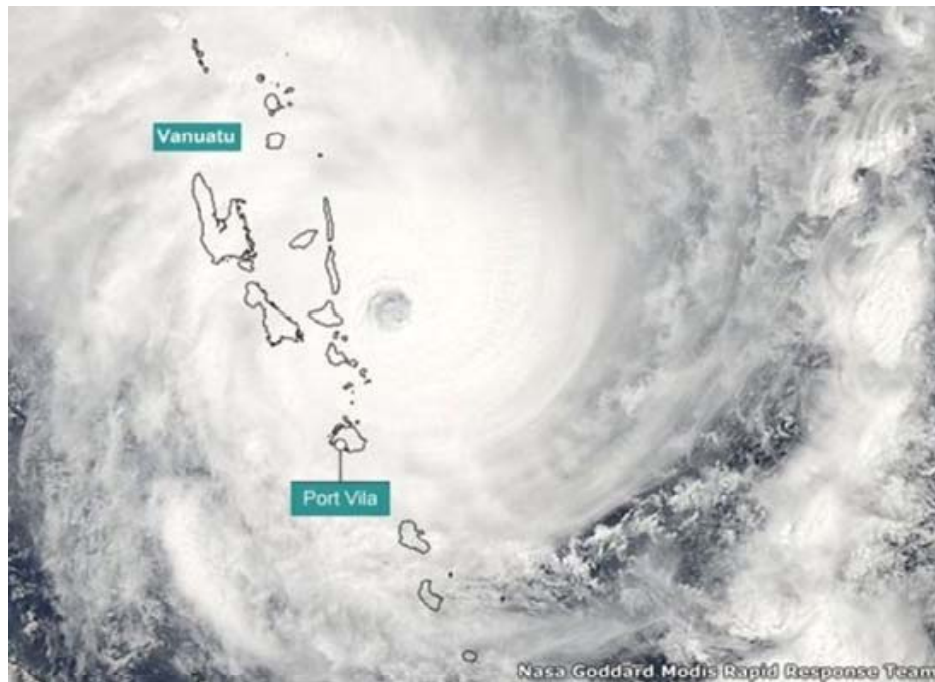
Heterogeneity of malaria prevalence by PCR on islands in Vanuatu 2011-2017

Number of PCR positives

	Islands	Examined	Total	PR(%)	<i>P. falciparum</i>	<i>P. vivax</i>	<i>P. malariae</i>
North	6	5548	334	6.0%	12	322	0
South	4	7573	1	0.0%	0	1	0

Year/Island	Examined	Total	PR(%)	<i>P. falciparum</i>	<i>P. vivax</i>	<i>P. malariae</i>
2011 Epi	558	39	7.0%	12	27	0
2011 Ambae	370	45	12.2%	0	45	0
2014 Ambae	1026	20	2.0%	0	20	0
2015 Maewo	1286	72	5.6%	0	72	0
2017 Malakula	1357	72	5.3%	0	72	0
2017 Santo	926	86	9.3%	0	86	0
2017 Gaua	603	0	0.0%	0	0	0

**On Friday, 13 March 2015
Cyclone Pam ripped through
the Vanuatu archipelago**



**9 April 2015, Tanna
4 weeks after the Cyclone**



Malaria prevalence by PCR on southern islands in Vanuatu 2011-2016

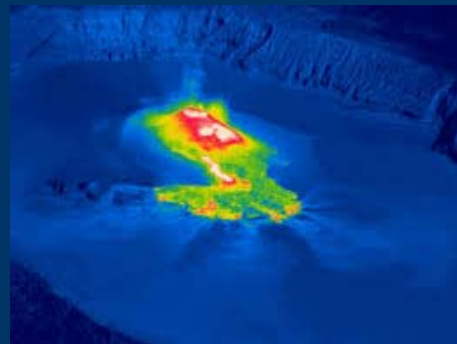
Year/Island	Examined	Number of PCR positives				
		Total	PR(%)	<i>P. falciparum</i>	<i>P. vivax</i>	<i>P. malariae</i>
2011 Futuna	225	1	0.4%	0	1	0
2013 Aneityum	1093	0				
2014 Tanna	533	0				
2015 Aneityum	1085	0				
<i>Afeter Cyclone Pam</i>						
2015 Aneityum	924	0				
2015 Tanna	1140	0				
2015 Erromango	940	0				
2016 Aneityum	903	0				
2016 Tanna	725	0				

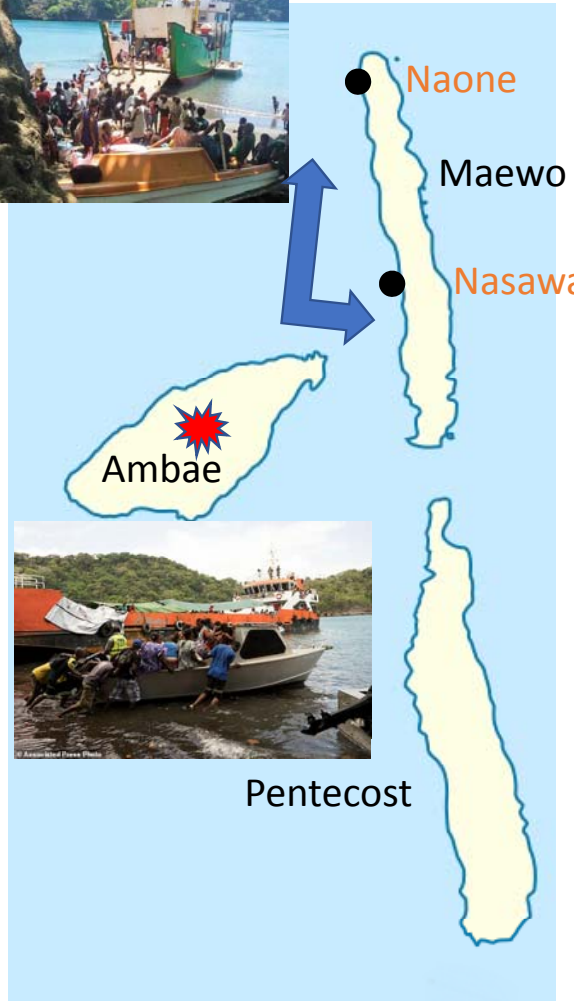
(Chan et al. 2017)

Vanuatu on Thursday ordered the full evacuation of the South Pacific nation's northern island of Ambae as a volcano there threatened to erupt.



- [Reuters News Agency](#)
28 SEPTEMBER 2017 • 4:07PM





Surveillance by community microscopist on Aneityum since 1993



Active case detection for all arriving passengers



Passive case detection for fever cases in community



Sustainable use of ITNs on Aneityum island, 2014

Sustainable ITN compliance on Aneityum, February 2014

- Households = 296
- Family members = 1199
- Slept under net last night = 1141 (95%)
- Total number of nets = 1259
 - New nets, distributed in 2012 = 766 (61%)
 - Old nets = 493 (39%)

Integrated community-directed strategies for the last parasites in Vanuatu:

Combatting residual *Plasmodium vivax* submicroscopic infections

- Sustainable ITN use
- Sustainable community-directed surveillance
- Molecular surveillance
 - Serological surveillance
- MDA with primaquine in transmission focus
- Awareness and **nudge** people to minimize risk of infections in self, family and community towards achievement of complete malaria elimination on islands

Acknowledgement

Peoples on islands in Vanuatu

- Osaka City University
 - Isao Teramoto
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 - Morris Kalkoa
 - Karo Kalkoa
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 - James Javiong
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 - Chris Drakeley
- Stockholm University
 - Marita Troy-Blomberg
- Ehime University
 - Takafumi Tsuboi
- Otaru University of Commerce
 - Tomoya Matsumoto



lessons from findings in behavioral economics

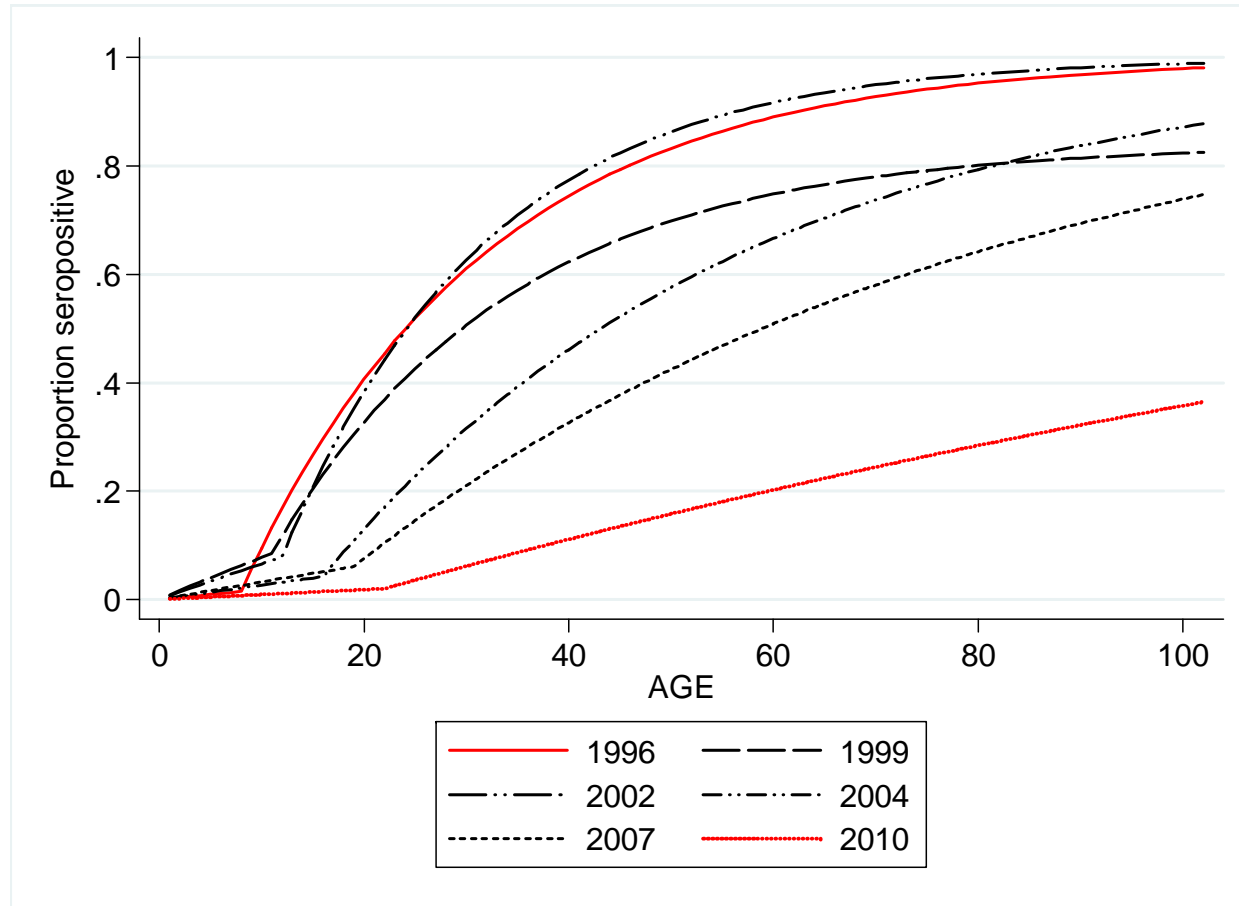
- Low level of people's awareness on transmission mechanism of malaria
- Positive externality of individual actions for the prevention and treatment to eliminate malaria – “free rider problem”

How to **nudge** people to minimize risk of infections in self, family and community towards achievement of complete malaria elimination on islands in Vanuatu

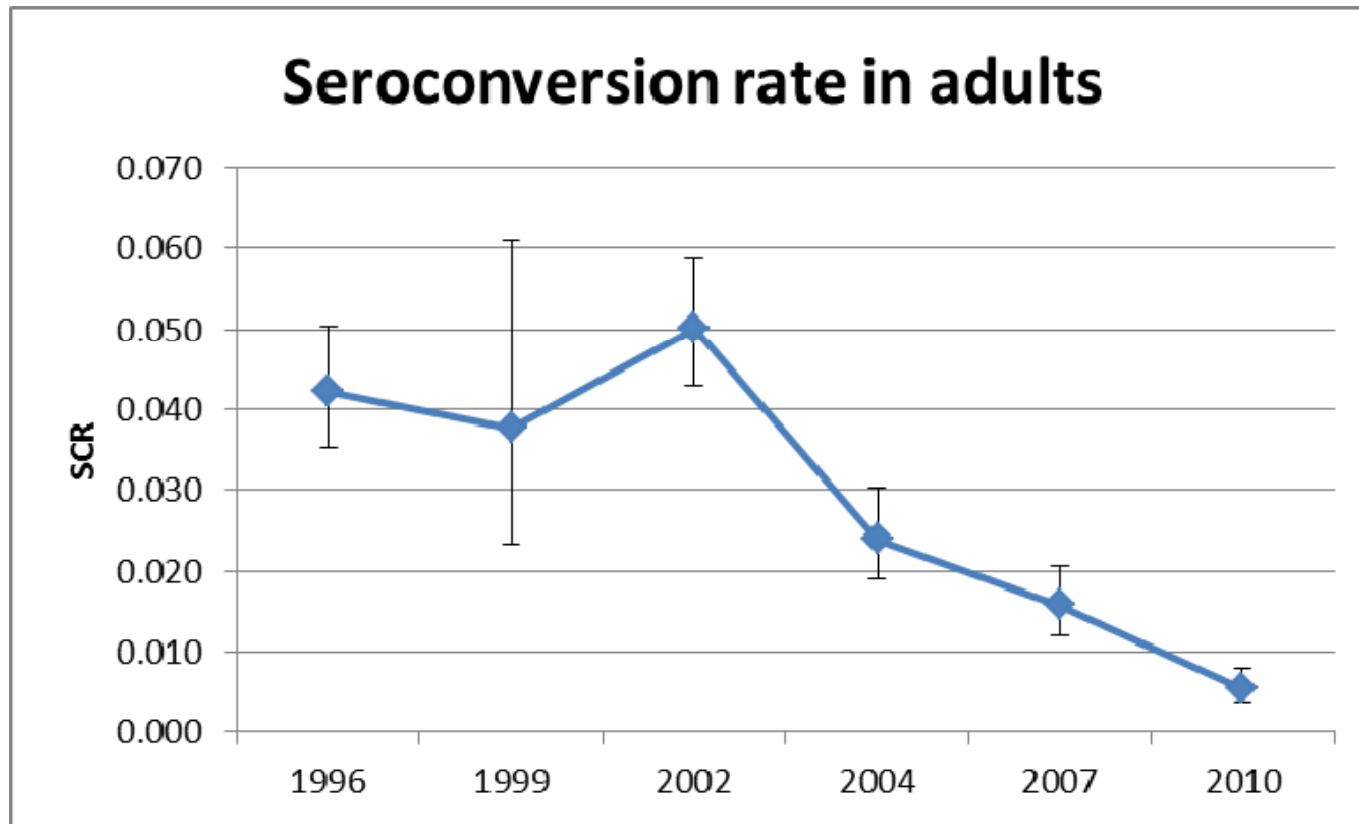
Ex. A black housefly into each urinal -----! (Richard H. Thaler 2008)

- Individual actions for prevention and treatment bring the benefit to not only themselves but also others who reside nearby or have interactions with them by reducing the risk of malaria infection.
- This **positive externality** of individual actions for prevention and treatment causes so-called “**free-rider problem**”, in which individual voluntary efforts for prevention and treatment tend to be less than the socially optimal level because individuals get benefits from others’ efforts and hence exert lower efforts for prevention and treatment on their own (Fisman et al, 2009; Cohen and Dupas, 2010; Ibuka et al, 2014).

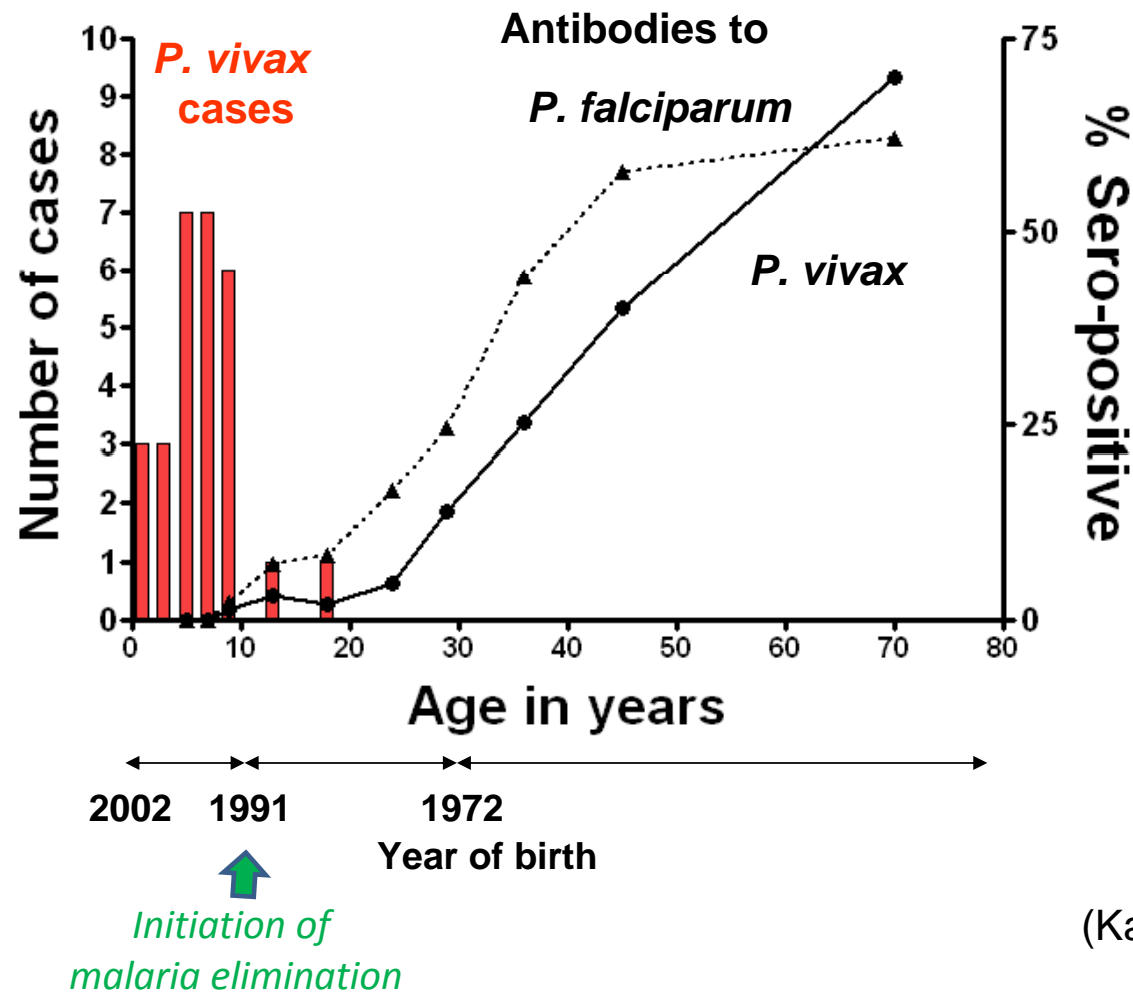
Seroprevalence curves of IgG antibodies to *P. falciparum* schizont extracts on Aneityum island, where malaria elimination initiated in 1991



Aneityum island: intervention in 1991



P. vivax outbreak on Aneityum island in 2002, a decade after MDA in 1991



(Kaneko A et al. 2014)

Malaria survey on islands of Epi, Malakula, Sanro, July – August 2018

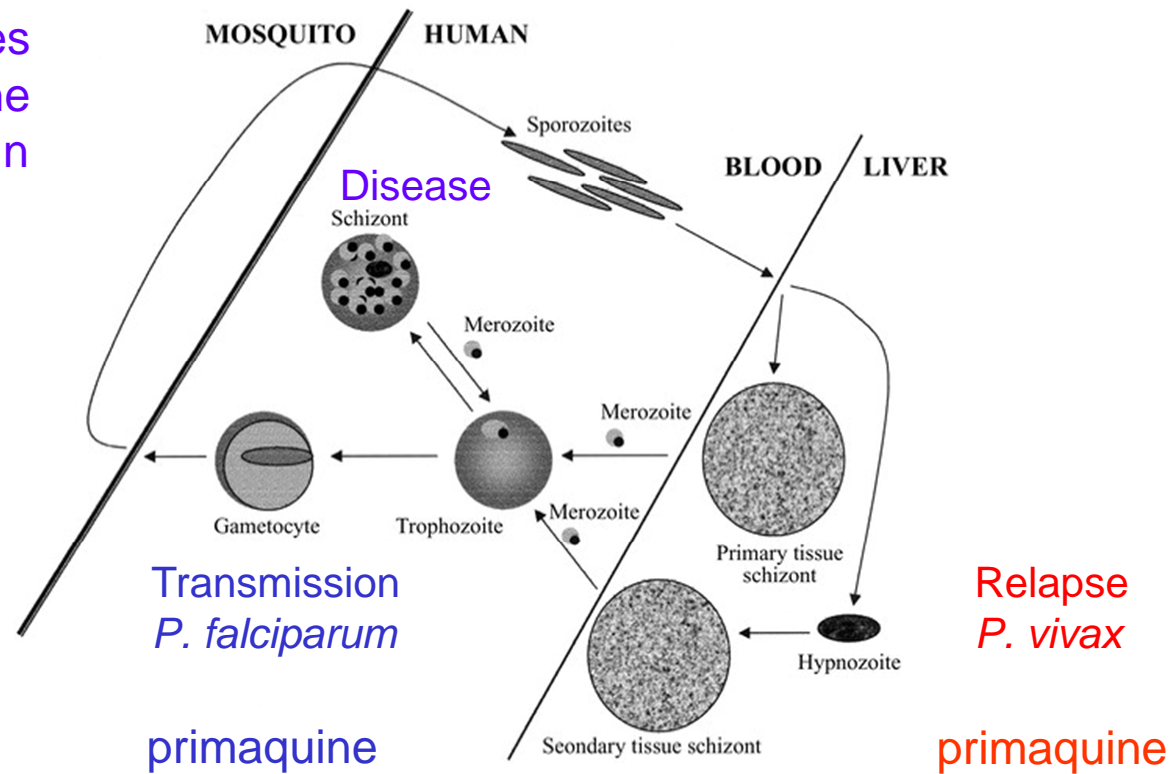
Island	Community	Examined by RDT	Positive by RDT	Species
Epi	Luo, Brisbane Nikaura Nubi, Locopui	500	8 (1.6%)	8 <i>P. vivax</i>
Santo	Mataroi Vusilolo Belview	540	9 (1.7%)	3 <i>P. falciparum</i> 5 <i>P. vivax</i> 1 Mixd of <i>P.f.</i>
Malakula	Dravai Burbar Pelongk Farun Lanvitvit	1062	4 (0.4%)	4 <i>P. vivax</i>

PCR?

Plasmodium life cycle and antimalarial drugs

Clinical use

- quinine
- chloroquine
- anti-folates
- mefloquine
- artemisinin



Malariometric surveys on islands in Vanuatu, 1987-2018

