Designing a Long-Term Effectiveness Model of Next-Generation LLINs Using R Software

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Overview of LLINs

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Components of a Long-Term Effectiveness Models

Pyrethroid-treated Nets (OlysetTM)

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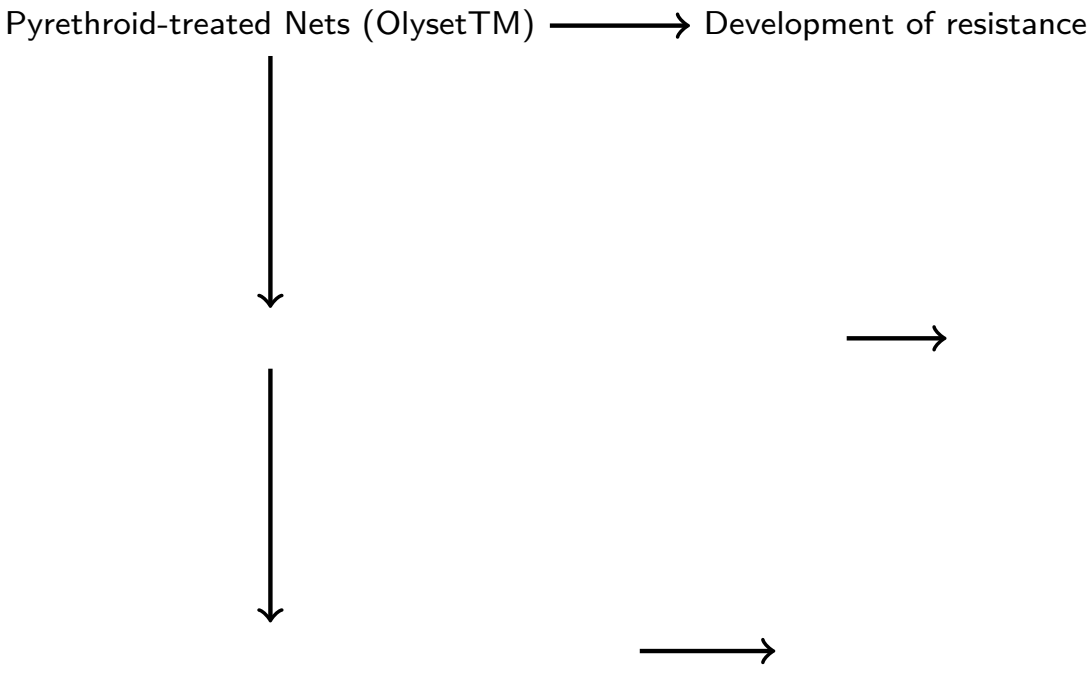

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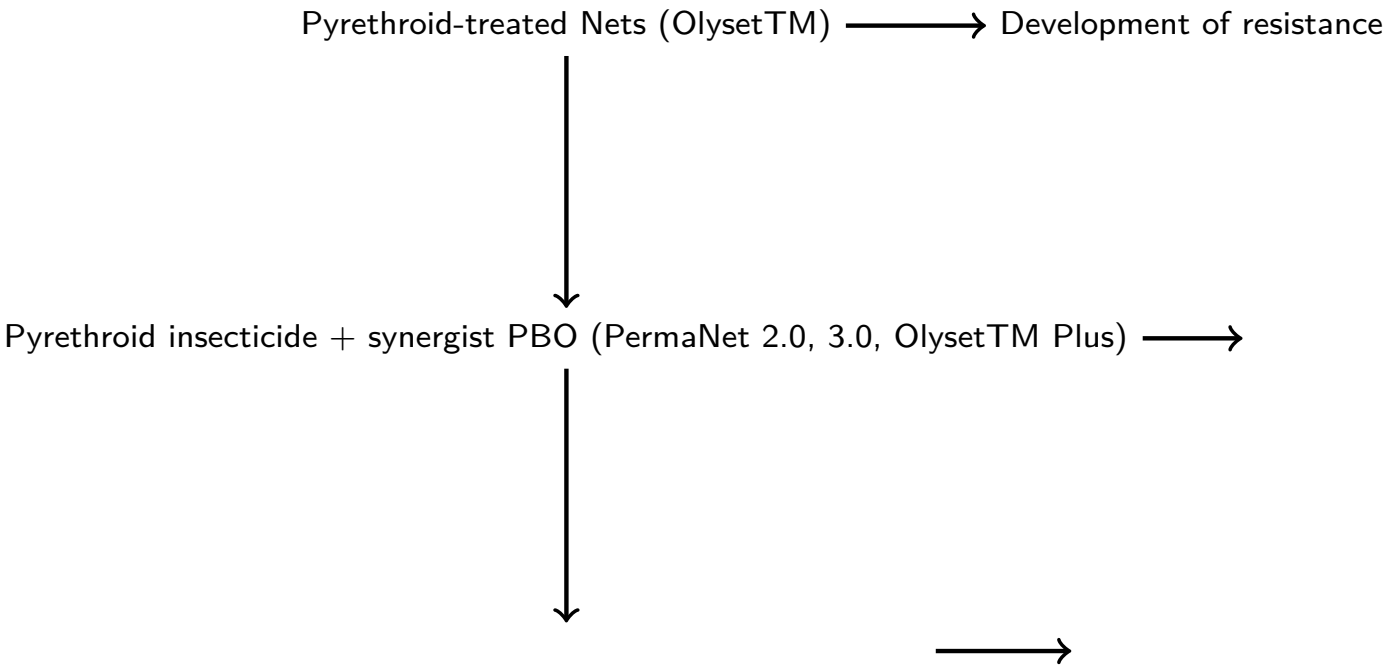

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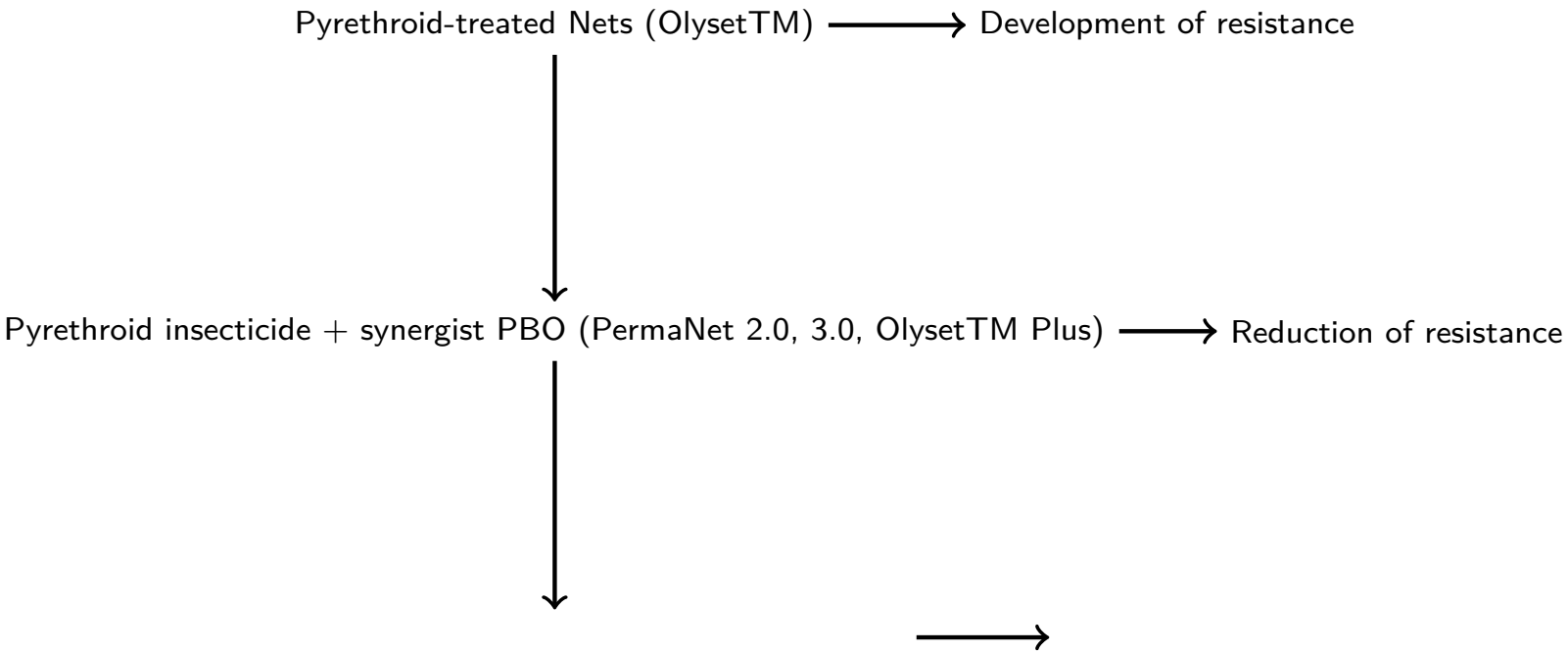

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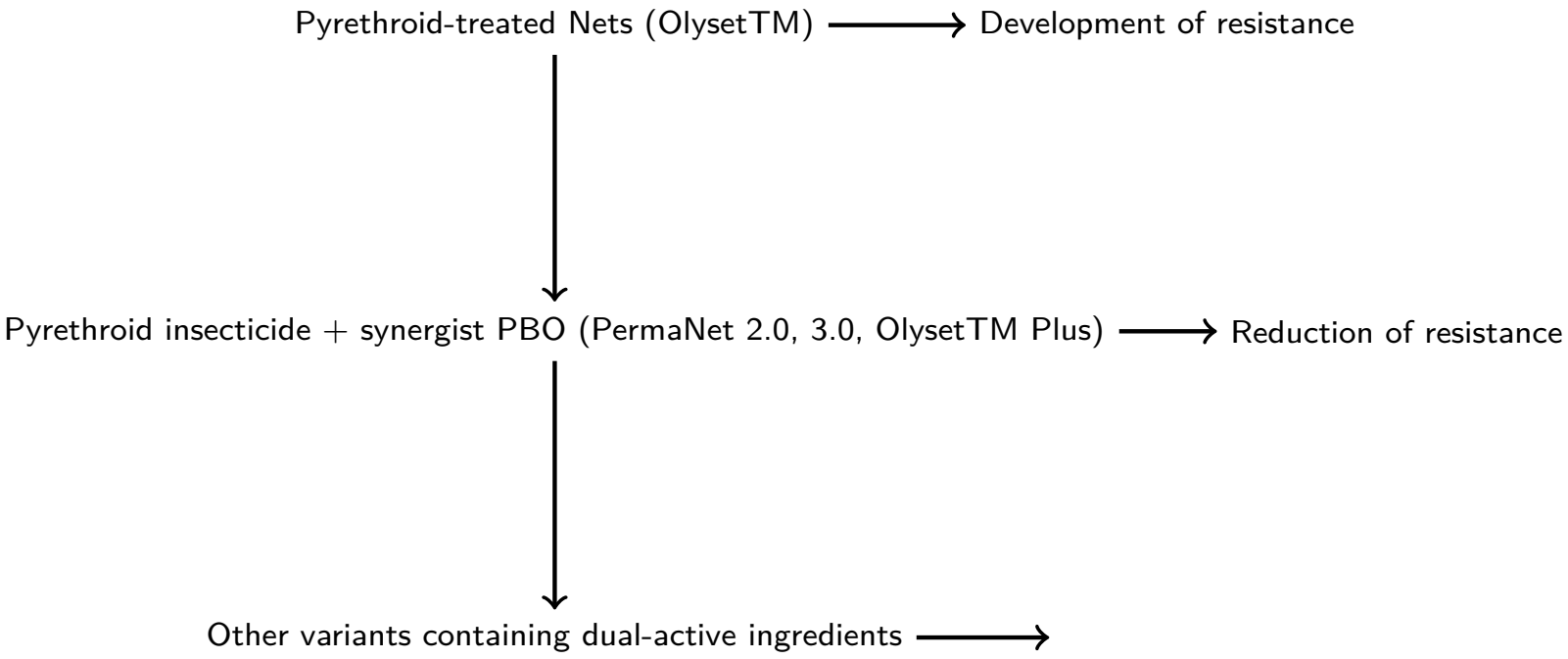

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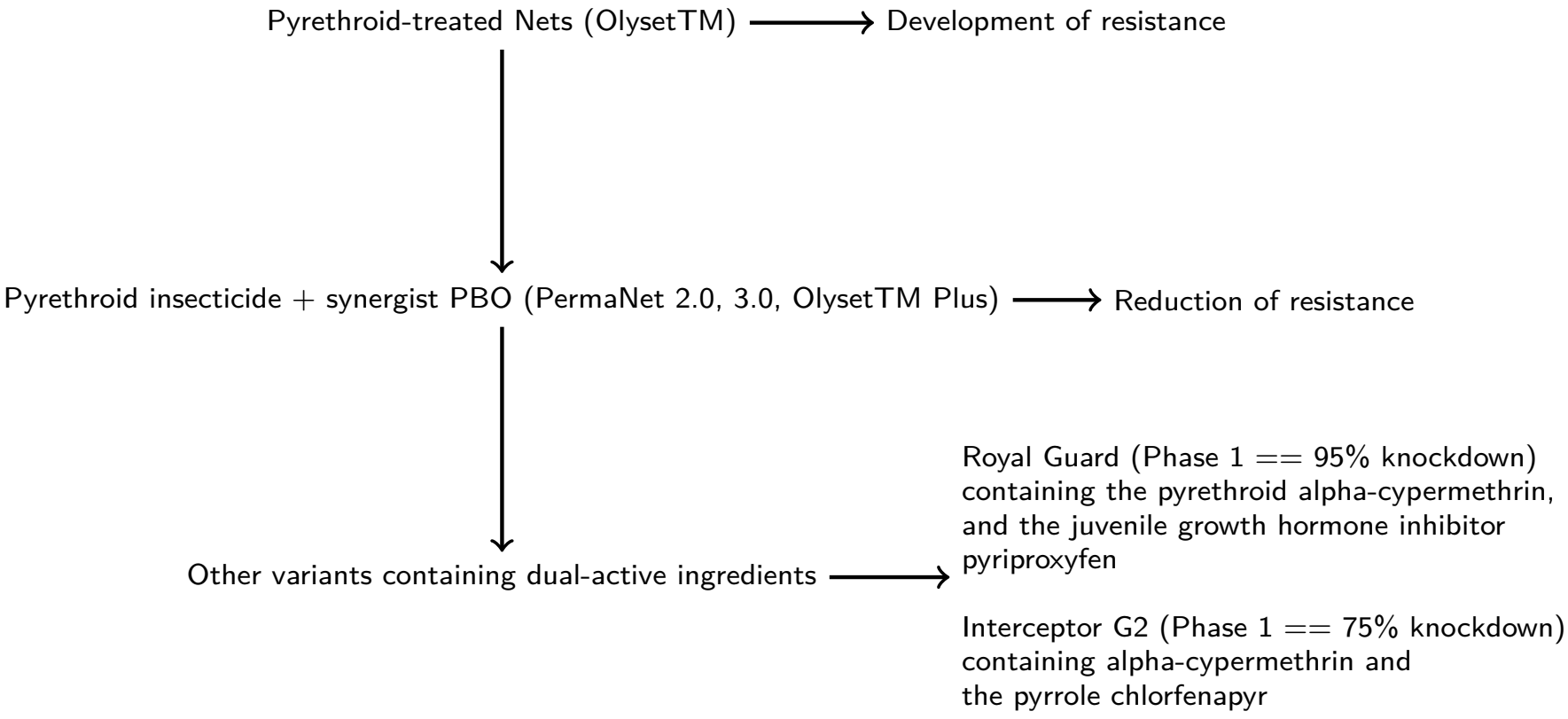

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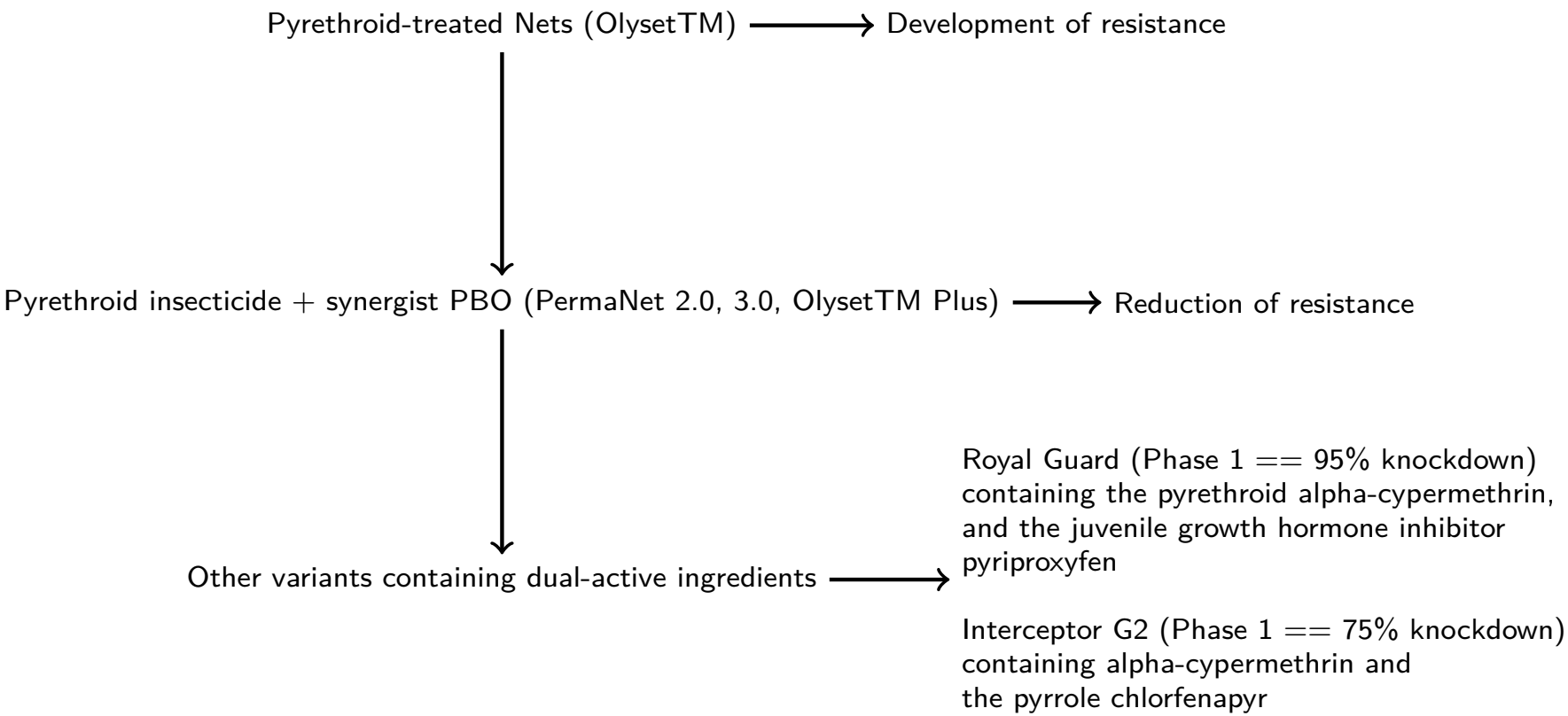

Additional LLINs Brake et al. 2022

Summary of commercially available LLINs

Name	Material	Insecticide	Dose (g/kg)	Denier	Reference
World Health Organization qualified/prequalified					
Olyset Net	Polyethylene	Permethrin	20.0	150	Tarimo & Cosmas (2018); WHO (2020d)
Olyset Plus	Polyethylene	Permethrin	20.0	150	Oumbouke et al. (2019); WHO (2020d)
		PBO	10.0		
Veeralin	Polyethylene	Alpha-cypermethrin	6.0	130	Oumbouke et al. (2019); WHO (2020d)
		Piperonyl butoxide	2.2		
MAGnet	HDPE	Alpha-cypermethrin	5.8	150	Oumbouke et al. (2019)
Permanet 2.0	Polyester	Deltamethrin	1.8	75	Wills et al. (2013); WHO (2020d)
			1.4	100	
Interceptor	Polyester	Alpha-cypermethrin	6.7	75	Lissenden (2020); WHO (2020d)
Interceptor G2	Polyester	Alpha-cypermethrin	3.2	75	Bayili et al. (2017); Lissenden (2020); WHO (2020d)
			2.4	100	
		Chlorfenapyr	6.4	75	
			4.8	100	
Royal Sentry	HDPE	Alpha-cypermethrin	5.8	150	Lissenden (2020); WHO (2020d)
Royal Sentry 2.0	HDPE	Alpha-cypermethrin	5.8	120	Lissenden (2020); WHO (2020d)
Royal Guard	HDPE	Alpha-cypermethrin	5.5	120 or 150	Lissenden (2020); WHO (2020d)
		Pyriproxyfen	5.0		
Permanet 3.0	Polyester	Deltamethrin	Roof: 4.0	75 or 100	Tungu et al. (2010); Lissenden (2020); WHO (2020d)
			Side: 2.8	75	
			Side: 2.1	100	
		Piperonyl butoxide	Roof: 25	75 or 100	
Duranet	HDPE	Alpha-cypermethrin	5.8	150	Lissenden (2020); WHO (2020d)
Duranet Plus	HDPE	Alpha-cypermethrin	6.0	150	Lissenden (2020); WHO (2020d)
	LDPE	Piperonyl butoxide	2.2		
Miranet	HDPE	Alpha-cypermethrin	4.5	135	Lissenden (2020); WHO (2020d)
Yahe	Polyester	Deltamethrin	2.3	50	Lissenden (2020); WHO (2020d)
			1.85	75	
			1.4	100	
Safenet	Polyester	Alpha-cypermethrin	6.7	75	Lissenden (2020); WHO (2020d)
			5.0	100	
Yorkool	Polyester	Deltamethrin	1.8	75	Ketoh et al. (2018); Lissenden (2020)
			1.4	100	
Panda Net 2.0	Polyethylene	Deltamethrin	1.8	75	UNICEFF (2020); WHO (2020d)
			1.4	100	
Tsara	Polyethylene	Deltamethrin	2.5	120	Lissenden (2020)
Tsara Boost	Polyethylene	Deltamethrin	3.0	130	Kasinathan et al. (2019); Lissenden (2020)
		Piperonyl butoxide	11.0		
Tsara Soft	Polyester	Deltamethrin	2.7	75	Lissenden (2020); WHO (2020d)
			2.0	100	
				150	
Reliefnet Reverte	Polyethylene	Deltamethrin	1.8	120	WHO (2021)
Tsara Plus	Polyester	Deltamethrin	Roof: 3.0; Sides: 2.5	Roof: 130; Sides: 100	Lissenden (2020); WHO (2020d)
		Piperonyl butoxide	Roof: 11.0		
Not approved					

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- The diffusion rate of an insecticide in a polymer matrix is typically described by Fick's Law of Diffusion. Fick's Law is a fundamental equation governing diffusion, and it can be expressed as follows:

$$J = -D\frac{dC}{dx} \tag{2}$$

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- **Contact irritant**: a chemical that stimulates mosquitoes to move away from the source after physical contact occurs.
- **Endophagy**: species that have a preference to feed indoors.
- **Endophily**: an inherent tendency to rest indoors after feeding (mosquitoes may feed indoors or outdoors).

Key Entomological Concepts

Some mosquito behaviors are relevant to LLIN effectiveness

- **Biting habits** refer to the fact that mosquitoes are most active from dusk to dawn. However, depending on the species, mosquitoes may also bite during the day. For example, Aedes mosquitoes feed during the day, while Culex mosquitoes feed mostly at night.
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- **Vectorial capacity (VC)**: the total number of infectious mosquito bites on humans that will arise from a single infected person on a single day. VC is a measure used in epidemiology to assess the potential for a vector population to transmit a pathogen to humans. It is often associated with the transmission of vector-borne diseases such as malaria. The basic formula for calculating vectorial capacity is:

$$VC = \frac{ma^2 p^n}{-ln(p)} \tag{3}$$

where m: The number of female mosquitoes per person. It quantifies the density of mosquitoes in the population; a:The human biting rate, representing the average number of bites a mosquito takes on a human per day; p The daily survival rate of mosquitoes. It denotes the probability that a mosquito survives each day; n: The extrinsic incubation period, referring to the time it takes for the pathogen to develop inside the mosquito before it can be transmitted.

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Key Entomological concept - End

- **Entomological Inoculation Rate (EIR)**:is a measure used in epidemiology to estimate the average number of infectious mosquito bites that a person receives in a specific period, typically per year. It is a critical parameter in understanding the transmission dynamics of vector-borne diseases, such as malaria. The formula for calculating EIR is as follows:

$$EIR = \frac{a \times m \times b \times p}{s} \tag{4}$$

where a: The human biting rate, indicating the average number of mosquito bites on a person per night; m: The sporozoite rate, which is the proportion of mosquitoes in the population that are infected with the pathogen and capable of transmitting it; b: The probability that a mosquito bite results in a transmission event (probability of transmission per bite); p: The daily survival rate of mosquitoes, representing the probability that a mosquito survives each day; s: The duration of the sporogonic cycle, which is the time it takes for the pathogen to develop and become infective inside the mosquito.

Initiation to R

- Gentle initiation to R
- What else can R be used for?
- Let's get our hands dirty

Crunching Numbers

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```
plot(mtcars$mpg, mtcars$hp, main = "Miles per Gallon vs Horsepower", xlab = "Miles per Gallon",
```

Computation of VC and EIR

- Hands -on

Application using real-world data

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Prediction

- Here we investigate determinants of mortality
- Detail is available here

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- Example

Thank You