Indeed, in sub-Saharan Africa, despite being found across a wide array of locations, numerous (so called “secondary”) mosquito species such as *Anopheles \_\_\_\_, Anopheles \_\_\_\_* and *Anopheles \_\_\_\_\_* contribute to transmission in only a limited manner, typically when other (“primary”) species such as *Anopheles gambiae*, *Anopheles funestus*, *Anopheles arabiensis* etc have seen their numbers reduced through intensive vector control efforts (Ref).

**Uncertainty About the Exact Link Between Mosquito Dynamics and the Temporal Profile of Malaria Risk**

* Whilst the relationship between the temporal profile of malaria risk and mosquito population dynamics is of course correlated, the nature and extent of this relationship, and how it varies within species, remains less clear. To that end, whilst we’re able to delineate and explore the temporal dynamics of mosquito populations, which will most certainly have implications for malaria transmission, our work has several important limitations worthy of note. These include:
  + Due to the extensive heterogeneity in sampling methods used to catch mosquitoes, we are unable to also explore variation in abundance of mosquitoes (instead having to use normalised time series). Thus, we are limited in our ability to translate a given temporal pattern into metrics relevant to malaria transmission, e.g. the EIR.
  + Superimposed on top of this is the fact that not all mosquito species are equally relevant to transmission. Whilst this is mitigated to an extent by the fact that we’ve constrained our analyses to mosquito species known to be big players in the transmission of malaria in India, there is evidence to suggest that the contributions of these different vectors to transmission is variable and genuinely different (e.g. *Anopheles culicifacies* as the dominant vector in many scenarios). Although this is perhaps more context dependent than has previously been thought (e.g. Ashwani’s paper revealing a role for *Anopheles subpictus* in sustaining malaria transmission), the lack of available information on vector competency limits our ability to directly relate observed temporal dynamics to malaria transmission.
  + Similar argument applies to the lack of comparison with epidemiological data (which might allow us to begin to unpick these relationships). Additionally, seasonal variation in non-mosquito related factors relevant to transmission such as mosquito exposure (possibly due to seasonal labour in high-risk settings) could further muddy the relationship between mosquito dynamics and malaria risk.

**Limited Predictive Performance**

* + More refined and spatially resolved environmental covariates – the incomplete and often ambiguous nature of location descriptions in papers precluded exact delineation of the sampling site in many instances. This, combined with the fact that the covariates used here were aggregated to a large spatial scale (e.g. 25km2), means that important features of the microenvironment, including smaller water sources and fine scale variation in ambient temperature etc, is likely being missed, and are likely important factors influencing mosquito temporal dynamics.
  + Development of a new suite of environmental covariates. Those used here were for the most part, initially developed to map and define static phenomena – e.g. the spatial extent of malaria prevalence, mosquito presence/absence. Whilst recent efforts have sought to incorporate temporally variable variables, they’re still the same features. Likely that different (possibly overlapping) features define presence/absence vs temporal dynamics. Development of new covariates, such as the distance to water bodies initially developed here, will likely further facilitate and refine predictive capacity.
* Whilst performing significantly better than a random classifier, an important caveat to this work is that the predictive capability of the model utilised here requires substantial improvement. Reasons for this/how to improve:
  + Our work highlights that the extensive variation in mosquito population dynamics observed can be mapped and aggregated into a small number of interpretable and policy relevant clusters. However, important to note that this clustering is ultimately a crude aggregation of what are likely continuous processes that shape the timing and extent of seasonality in mosquito population dynamics.
  + The use of more complex methods incorporating interactions and complex dependencies between covariates (e.g. Boosted Regression Trees, Neural Networks or similar).
  + More refined and spatially resolved environmental covariates – the incomplete and often ambiguous nature of location descriptions in papers precluded exact delineation of the sampling site in many instances. This, combined with the fact that the covariates used here were aggregated to a large spatial scale (e.g. 25km2), means that important features of the microenvironment, including smaller water sources and fine scale variation in ambient temperature etc, is likely being missed, and are likely important factors influencing mosquito temporal dynamics.
  + Development of a new suite of environmental covariates. Those used here were for the most part, initially developed to map and define static phenomena – e.g. the spatial extent of malaria prevalence, mosquito presence/absence. Whilst recent efforts have sought to incorporate temporally variable variables, they’re still the same features. Likely that different (possibly overlapping) features define presence/absence vs temporal dynamics. Development of new covariates, such as the distance to water bodies initially developed here, will likely further facilitate and refine predictive capacity.
* . Interestingly, this is observed extensively both between species (such as the differences displayed by *Anopheles dirus* and *Anopheles fluviatilis*), but also within species (as evidenced by the wide array of temporal modalities *Anopheles culicifacies* populations displayed across the different study sites). This latter phenomenon highlights the plasticity of the dynamics of some mosquito species
* Whilst our results suggest in a limited number of circumstances (e.g. *Anopheles fluviatilis* and *Anopheles dirus*) that mosquito population dynamics are driven primarily by species specific traits and preferences, they also highlight the important role of the environment in determining these dynamics. Indeed, for a number of species (such as *Anopheles culicifacies*, *Anopheles subpictus* and *Anopheles stephensi* amongst others), we show that temporal variation in their population dynamics depends intimately on the ecological structure of the local environments.

**Discussion Rough Skeleton:**

1. Understanding temporal dynamics is important but lots of uncertainty remains. Here we show… which allows us to… this is important because…
2. Extensive diversity in mosquito population dynamics – between species (fluviatilis peaks in dry season, annularis knocking around a lot of the time etc). Species effects dominate for fluviatilis here.
3. Extensive diversity in mosquito population dynamics – within species (culicifacies, subpictus and their occupation of different clusters). Supports the idea that for a given species, the temporal dynamics displayed show extensive ecological structuring - i.e. that they depend intimately on the structure of the local environment. Couple of examples from the ecological covariates to support e.g. isothermality.
4. Overall, show that the given mosquito population dynamics represent a complex interplay between biotic (e.g. species specific factors, captured by the species coefficients) and abiotic (e.g. location specific factors, captured by the ecological coefficient) factors, with the comparative importance of these two things varying across species – differential plasticity. For fluviatilis, species factors play more of a role, for culicifacies and subpictus (generalists), ecological factors – relate these to the ecological niche they occupy i.e. the latter two are more generalists/less fussy.
5. Limitations – see below
6. Despite this however…
7. Understanding the temporal dynamics (including the start, duration and end) of malaria transmission in a given location represents a vital input to optimising control strategies – our work yields new insight into the drivers of malaria’s temporal dynamics and better resolves the complex interplay between the mosquito and its surrounding environment in the determination of these dynamics.
8. Overall, we provide a framework to enable the incorporation and synthesis of routinely collected entomological data. This is what’s available in the literature, but there’s likely tonnes that is routinely collected but not published – robust, statistically valid framework with which to use this data and enable predictions of operationally relevant information e.g. when to seasonally spray etc.

Similarly, *Anopheles subpictus* can breed in a variety of habitats ranging from fresh to brackish water and including highly polluted sources14, a feature that likely contributes to its capacity in sustaining year round malaria transmission in the urban setting of Goa, India15.

Previous studies have observed substantial variability in the temporal patterns of mosquito population dynamics in different species residing in the same location (suggesting that these dynamics can be independent of rainfall under some circumstances, and influenced by other factors17), as well as within species across different locations (with *Anopheles culicifacies* displaying dynamics ranging from intense seasonal peaks18 to more perennial patterns of abundance19).

The population dynamics of *Anopheles gambiae* were shown to be highly concordant with rainfall during extensive entomological investigations in the Garki District of Nigeria10. *Anopheles funestus* by contrast frequently displays a lack of the marked seasonal fluctuations in population abundance that characterises other anopheline species, a feature possibly attributable to its preference for large permanent/semi-permanent bodies of fresh water as its breeding habitat11 and thought to be a substantial contributor to the perennial malaria transmission observed across parts of Eastern Africa12,13. Similarly, *Anopheles subpictus* can breed in a variety of habitats ranging from fresh to brackish water and including highly polluted sources14, a feature that likely contributes to its capacity in sustaining year round malaria transmission in the urban setting of Goa, India15. Complicating matters further, not all variation in population dynamics appears to be species-specific, with numerous instances of variation in the seasonal dynamics displayed by the same species found across different locations e.g. as observed for *Anophleles annularis*, whose dynamics can range from near-perennial through to intensely seasonal16.

is suggests that the influence of rainfall on mosquito breeding site availability represents a complex combination of the intensity and duration of precipitation an area receives, species specific breeding site preferences (transient or permanent water bodies, polluted or clean water sources, observed for multiple species across both African and Asian settings11,20–22) and the ecological structure of the local hydrological.