Temporal variation in catch composition, fishing gear and time spent fishing in an artisanal coral reef fishery: An assessment through fishers' perceptions and experiences

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Introduction

Overfishing by small-scale fisheries has been recognised as a key threatening process for coastal fish stocks and biodiversity, both globally and across the Pacific Islands region (Sadovy de Mitcheson et al. 2013; Andrew et al. 2007; Newton et al. 2007; Sadovy et al. 2005). Surprisingly, our discussions with communities in several Pacific Island countries reveal that while local communities are generally well aware of, and worry about, the decline of local fish stocks, they rarely attribute it to their own fishing activities. Instead, they are most likely to attribute stock declines to changes they observe occurring in the natural environments around them, such as coastal development, mangrove cutting, coral bleaching and climate change. While these factors certainly contribute to the decline of coastal fish stocks, the length-based assessments we have been conducting reveal the major cause is depletion of reproductive potential through overfishing (Prince et al. 2015; Prince et al. in press), to the extent that even without environmental factors, we would expect these resources to be declining.

Our discussions also reveal a general lack of awareness, particularly among people young enough to be still actively fishing, about how much fishing has changed over time. Perhaps communities fail to recognise overfishing because they perceive their fishing practices to be one of the few aspects of life that have remained constant over many generations, and do not understand why it would have an effect now.

Worldwide it is recognised that human populations struggle to transfer information between generations, so that changes that occur slowly (over approximately 40-year intervals) are forgotten by successive generations. Instead, each generation presumes that the conditions they initially experience are the way things have always been, and so only take into consideration change that occurs during their own lifetime. In fisheries, this has been called the 'shifting' or 'sliding' baseline syndrome (Pauly 1995). It is recognised as impeding fisheries reform by preventing the full extent of fisheries depletions being appreciated, thus reducing the sense of urgency for management reform, as well as expectations for the long-term benefits to be derived. Correctly recognising the central role of local overfishing in the decline of coastal resources is important and can be empowering for Pacific communities. Armed with basic fisheries knowledge, communities can hope to directly address their own local overfishing by implementing fisheries management. In contrast, they can only hope to play small in-direct roles in solving the pressing national and global environmental degradation issues stemming from poor land-use policies and global warming.

With the aim of counteracting the shifting baseline syndrome among Pacific communities, this short paper documents the results of facilitated community discussions, describing changes in fishing practices and catches that have occurred over the last 50 years on Koro Island in the Lomaiviti Province of Fiji.

Method

The Wildlife Conservation Society (WCS), together with the Lomaiviti Provincial Office (LPO), implemented a two-day, community-based fisheries management training in Tuatua village on Koro Island, Lomaiviti, Fiji. The training was attended by community representatives from 11 out of the 14 villages on Koro Island (Fig. 1). The objectives of the training were to raise awareness about and train community members in the various fisheries management tools (Fig. 2) that the community could adopt in order to support their efforts in community-based fisheries management.

Within their respective villages and irrespective of gender, fishers were divided into two groups: old and young. Both groups were given the same topics to discuss, which included:

- the period of years during which they were (or are) most actively fishing (based on their year of birth);
- the amount of time they normally spent fishing each day;
- the type of fishing gear and fishing methods used;
- the types of boats used and the availability of fishing gear;
- the number of fishers participating in a normal fishing party; and
- the catch composition in terms of species, size and number.

At the end of the 45-minute discussions, groups were asked to present a summary of their discussions.

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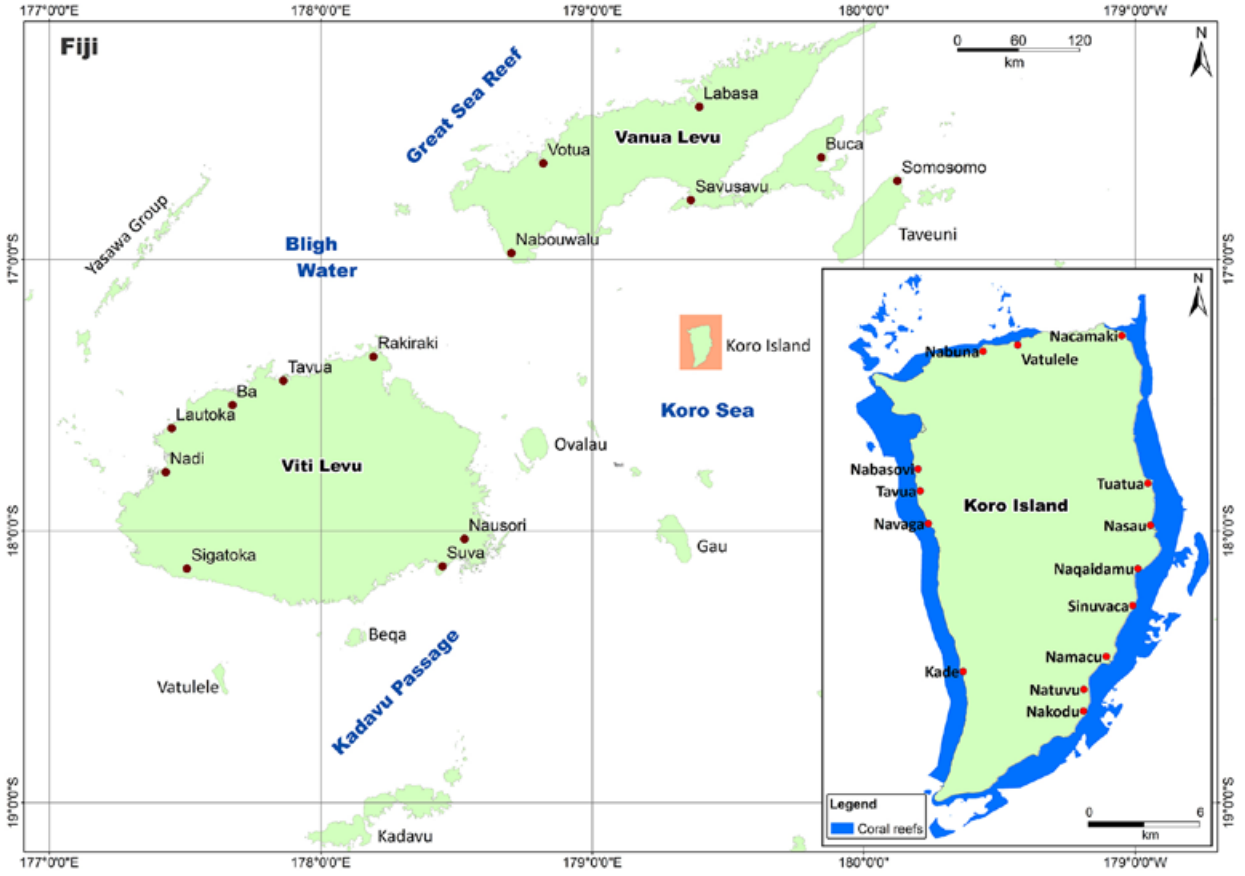

Figure 1. The location of Koro Island within Fiji, and an insert map showing the 14 coastal villages.

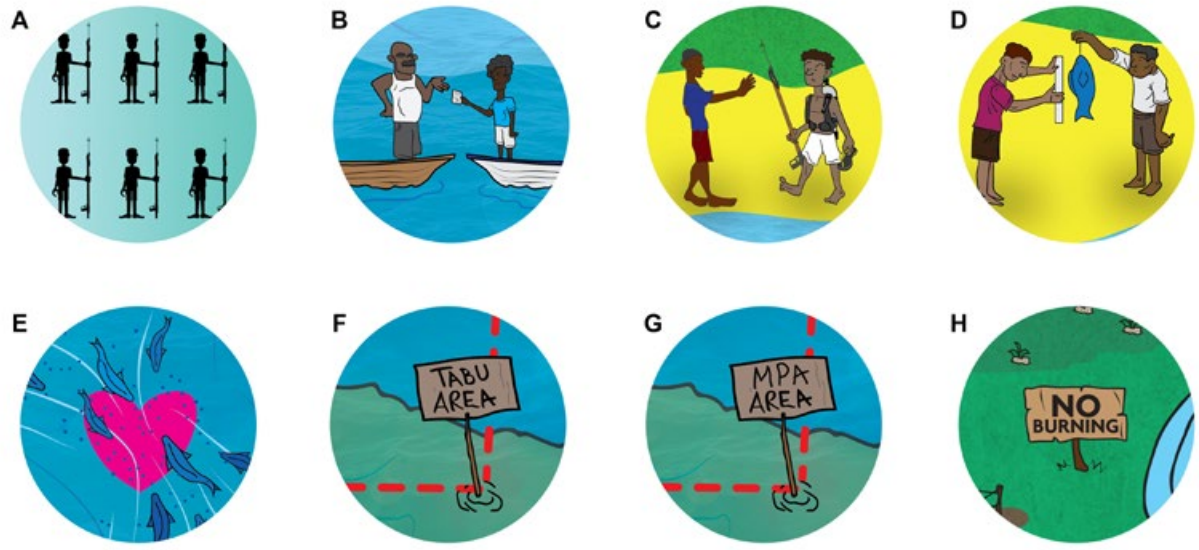

Figure 2. Fisheries managemet tools include: A) limiting the number of fishers, B) limiting the number of licenses granted, C) gear restrictions, D) minimum size limits, E) protecting spawning aggregation sites and/or species through seasonal bans, F) tabu areas, G) permanent no-take zones, H) rules for land use. ©cChange

Results

The results of the facilitated discussions provide a detailed insight into the changes to fishing that have occurred over the last 50 years (Table 1).

Traditional fishing methods

Older fishers reported that they fished from simple hand-propelled bamboo rafts (*bilibili*), canoes or punts without engines, which carried only 1 or 2 fishers. Older fishers also only fished for a couple of hours per fishing trip, and used a range of traditional techniques and gear types made from locally available materials: hand spearfishing (*cocoka*), fish weirs (*moka*), fish drives (*yavirau*) and cast nets (*lawa sua/lawa viri*). These techniques are rarely used today.

Hand spearfishing

Hand spearfishing (*cocoka*) involved throwing or thrusting a particular spear known as the '*moto saisai*' through the surface of the water. This method was used in rivers, intertidal areas, mangroves, reefs and even open water. Fishers typically caught jacks (Carangidae), emperors (Lethrinidae), rabbitfish (Siganidae), mullets (Mugilidae) and needlefish (Belonidae) with this method. Some hand spearfishing still continues, although over time, spears have been modernised so that today different types are used; some are still made from traditional materials of wood and coconut vine known as '*magimagi*' and others by combining a wooden handle with a pointed metal tip.

Fish weir/trap

Another traditional fishing method involved the permanent construction and maintenance of a horseshoe-shaped, boulder-walled trap or weir, locally known as '*moka*', which was used in the intertidal zone. For structural stability, a weir required a hard-bottomed shoreline, and the rocky shorelines of Namacu and Tuatua villages provided an excellent setting for these structures. To be effective, the weir had to be constructed with correctly angled stonewalls that helped

Table 1. Difference in fishing as experienced by old and young fishers.

Topics	Old fishers	Young fishers	Changes observed
Fishing period	1960s–1980s	2012–to present	1960s–present
Hours of fishing per day	1–2 hours (day fishing)	10–12 hours (day and night fishing)	Many more hours spent fishing per day
Fishing gear used	◦ *moka* (fish weirs) ◦ *cocoka* (thrust spearfishing) ◦ *lawa sua/lawa viri* (cast net) ◦ *qoli walai/yavirau* (fish drive) ◦ *cina coka* (night thrust spearfishing) ◦ *kilivati* (Hawaiian sling) ◦ *duva* (fish stun)	◦ nunu (spearfishing) ◦ nunu bogi (night spearfishing)	Fewer fishing methods practiced
Boat used	*bilibili* (bamboo raft) Boats without engines	Boats with engines	Nowadays, productive fishing grounds are farther away and require motorised boats
Availability of fishing gear and boat	Few fishing gear types and boats	Many types of fishing gear and boats with engine	Few fishing gear types available in 1960s–1980s compared to now
Main fish species caught	◦ *kawakawa* (grouper) ◦ *donu* (coral trout) ◦ *varivoce* (humphead wrasse) ◦ *kalia* (bumphead parrotfish) ◦ *saqa* (giant trevally) ◦ *derekeni/sevaseva* (sweetlips) ◦ *ogo* (barracuda) ◦ *walu* (Spanish mackerel)	◦ *kabatia and sabutu* (emperors) ◦ *cucu* (goatfish) ◦ *balagi* (surgeonfish) ◦ *nuqa* (rabbitfish)	Old fishers' catch was mostly composed of larger-bodied and A-grade fish species. At present, catch is mostly composed of fewer and smaller fish species
Size of fish caught	Large	Small	Smaller fish are caught nowadays than in the past
Number of fishers	Few	Many	Fewer fishers in the 1960s and 1980s compared to now

to guide fish moving along the shoreline into a retaining area. The top of the wall was built up to a level that would be covered by at least 0.5–1.0 m of water at spring high tide, thus allowing fish to enter, but be above the surface of the water during low tide so as to trap the fish within the weir. The landward face of the weir tended to be vertical, thereby providing fish inside with reassuringly deeper water close to shore, while the seaward face sloped gently to seaward minimising turbulence from incoming waves and easing access into the weir. Entrapped fish were speared at low tide. The species commonly caught with this method were: thumbprint emperor, *kabatia* (*Lethrinus harak*), bluefin trevally, *saqa ni vatu* (*Caranx melampygus*), Picasso triggerfish, *cumu* (*Rhinecanthus aculeatus*), honeycomb grouper, *senikawakawa* (*Epinephelus merra*), crescent-banded grunter, *qitawa* (*Terapon jarbua*) and blacktip silver biddy, *matu* (*Gerres oyena*).

Remnants of fish weirs are still present in many locations as some communities were using them up until Tropical Cyclone Winston, although other communities in our study area stopped using them earlier, when fishing *tabus* which extended from the shoreline to the outer reef, were implemented.

Fish drives

In Koro, fishers traditionally used community fish drives, known as *yavirau* or *qoliwalai*, which required cooperative prior planning of intended target species and employed a rope sweep, which was used on the agreed day and at the right part of a tidal cycle. The sweep was made with coconut fronds and vines that were woven together to form a long rope. The coconut fronds were wrapped around the rope to form a hanging skirt-like structure for sweeping across the coral shallows. Using the sweep, fish were herded through the coral shallows into a small area where they could either be scooped up with traditionally made nets (now monofilament gillnet is used), or by hand spearing. Depending on the number of people available to assist with the drive, a greater or lesser amount of coconut fronds would be wound into the rope. The more people and pairs of legs along the rope, the fewer the gaps that need filling with coconut fronds so that the fish can't escape.

The main species caught include with the rope sweep were: bluefin trevally, leopard coral grouper, *Plectropomus leopardus* (*donu damu*), and grouper (*kawakawa*), longface emperor, *L. olivaceus* (*dokonivudi*), thumbprint emperor and Pacific yellowtail emperor, *L. atkinisoni* (*sabutu*), steephead parrotfish, *Chlorurus microhinos* (*ulurua*), rivulated parrotfish, *Scarus rivulatus* (*kakarawa*) and bullethead parrotfish, *C. sordidus* (*kakarawa*), Achilles tang, *Acanthurus achilles* (*dridri*), yellowfin surgeon fish, *Acanthurus xanthopterus* (*balagi*), orangeband surgeonfish, *A. olivaceus* (*balagi nawa*) and lined bristletooth, *Ctenochaetus striatus* (*meto*), vermiculate rabbitfish, *Siganus vermiculatus* (*volaca*) and streamline spinefoot, *S. argenteus* (*nuqa*), humphead wrasse, *Chelinus undulatus* (*varivoce*), Picasso triggerfish and yellow margin triggerfish, *Pseudobalistes flavimarginatus* (*qau*) and mangrove red snapper, *Lutjanus agentimaculatus* (*damu ni veidogo*), two spot red snapper, *L. bohar* (*bati*) and humpback red snapper, *L. gibbus* (*bo*).

In Koro the *yavirau* is still employed one or two days before Christmas and New Year's, specifically for villagers returning to the village for the holidays.

Fish poison

Fish poison or *duva* is carried out using either *vutu* fruit (*Barringtonia asiatica*) or the roots of a certain vine (*Derris* spp.). Both plants contain a poison strong enough to stun or kill fish. The plant material is pounded before being wrapped in a cloth and then squeezed into tidal pools or under a rock or coral head where the poison leaches out and stuns the fish. Stunned fish then float to the surface where they can be easily collected. A wide range of species are caught using this method.

Modern fishing gear and methods

Younger fishers engage most intensively in speargun fishing, particularly at night (*nunu bogi*) and also in gillnetting and trolling, techniques that were not used 50 years ago (S. Kasanibuli, elder fisherman, pers. comm.). Fishing is mainly carried out in vessels powered with 15– 60 hp outboard motors, which typically now carry about four fishers per fishing trip, which generally last up to about 12 hours, either a whole day or an entire night.

Speargun fishing

Spearguns are mostly used by fishers who breath-hold dive with a mask, snorkel and fins in shallow water. With a clear view of fish underwater with a face mask, and the enhanced capacity for stalking fish, speargun fishing is much more efficient than traditional hand spearing. The main target species with this method included snappers, emperors, parrotfish, jacks, surgeons and groupers. Speargun fishing is practiced almost exclusively by young male fishers.

Night diving

Speargun fishing was initially practiced exclusively during daylight hours. As fish have become scarcer and warier of divers, daytime speargun fishing has been almost entirely replaced by night-time speargun fishing. With the assistance of an underwater torch, fishers are now able to search for fish sleeping among the corals at night.

Gill nets

Monofilament gill nets, held vertically in the water by a series of floats attached to the upper edge of a rope and lead weights along the bottom, are anchored in shallow water to

catch a range of species, including mullet, emperors, rabbitfish, parrotfish, goatfish and snappers. Gill nets have a mesh size designed to catch a specific size range of particular fish.

Trolling

Trolling mainly targets jacks, snappers and other pelagic fish species. It involves towing bright or reflective fluttering lures made of feathers or plastic along the surface behind slowly motoring boats.

Changes in catch composition

Through our facilitated discussions the older fishers bragged about their catches in the past, which comprised large-bodied groupers (*kawakawa*), coral trout (*donu*), humphead wrasse (*varivoce*), bumphead parrotfish (*kalia*), Spanish mackerel (*walu*) and barracuda (*ogo*) (W. Tora, elder fisherman, pers. comm.). Young fishers' catches comprise mostly smaller-bodied emperors (*kabatia* and *sabutu*), goatfish (*cucu*), surgeonfish (*balagi*) and rabbitfish (*nuqa*). Older fishers claim that catches of 270–750 kg per fishing trip were common, while younger fishers estimate current catches at 12–120 kg per fishing trip.

While it is worth noting that the historic figures are based on reminiscent community perceptions and may well be exaggerated to some extent, they still indicate the magnitude of change that has occurred over a relatively short time (30–50 years).

Discussion

The community discussions highlighted several key ways that fishing has changed.

From the 1960s to 1980s, modern fishing gear was not as commercially available as it is today, and was generally constructed with locally available materials. Not all community members had the skills required to making and use these traditional techniques. Older fishers emphasised that the combination of motorised vessels, underwater torches, spearguns, snorkelling gear and underwater breathing apparatuses have made fishing much more effective than traditionally made fishing gear. While a wider range of traditional fishing techniques were used in the past, they all tended to be more 'passive', in that fish could not be so actively pursued throughout their life cycle, depth range and habitats. To successfully deploy traditional methods, fish behaviour had to be known and understood, and taken advantage of in places and times of particular vulnerability. For example, fish weirs and drives only caught fish in particular shallow locations and certain tidal cycles, while hand spearing relied on being able to approach within very close range of shallow swimming fish. In contrast, outboard motors, spear guns and underwater torches, enable fishers to hunt and catch fish on almost every reef, throughout almost their entire depth range, and even while they are sleeping at night hidden among corals and rocks.

The facilitated discussions suggest that the observed shift in fishing techniques towards more effective but expensive fishing gear has been driven by a cascade of factors. Participants repeatedly observed that fishing increasingly yields fewer and smaller fish, and that bigger-sized fish have become extremely hard to find within customary fishing grounds. At the same time, the number of households per village continues to grow, meaning there are more mouths to feed and more income required. These trends have led to an increasing number of community members going fishing, and driving fishers to invest in more sophisticated fishing gear and fish for longer periods during each fishing trip, so as to maximise their catches in the face of declining resources.

Community participants often attributed the changes they observe in fish stocks to climate change, which they perceive as having an impact on every species group within the fishery. This in turn forces fishers to respond with new fishing gear, more fishers and longer fishing trips. We acknowledge that climate change is undoubtedly having a negative impact on coastal resources, particularly through the degradation of coral by bleaching and cyclone damage. However, our recently completed assessments of 29 Fijian reef fish species found that more than half (17) currently fulfill <20% of the natural reproductive potential ratio (SPR), the level internationally regarded as the minimum sustainable level, while less than half (14) are fulfilling <10% SPR, the level regarded as indicative of stock collapse (Prince et al. in press). Such low levels of reproductive potential are entirely due to heavy fishing pressure, which is reducing the reproductive life span of fish. In contrast, the signature of stock declines driven primarily by climate change or environmental degradation will be that lightly fished stocks completing relatively high levels of reproductive potential will never-the-less fail to maintain stock levels due to the loss of the productive habitat needed to sustain their populations. With fish currently being caught before completing minimal sustainable levels of reproduction, there is little need to invoke climate change as an additional cause of resource decline, and no evidence to suggest it is the primary cause of declining stocks at present.

Rather, the changes in catch composition described are indicative of the phenomenon observed around the world called 'fishing down the food web' (Pauly et al. 1998), by which fishers or hunters start off targeting the most preferred and largest-bodied species at the top of the food web (Fig. 3) until those species become depleted. Targeting then shifts down the food web, focussing on progressively smaller and smaller-bodied species, as each level of the food web is depleted in turn. It is this phenomenon that results in fishers competing more intensively for fewer and smaller fish with increasingly effective gear and spending more time fishing.

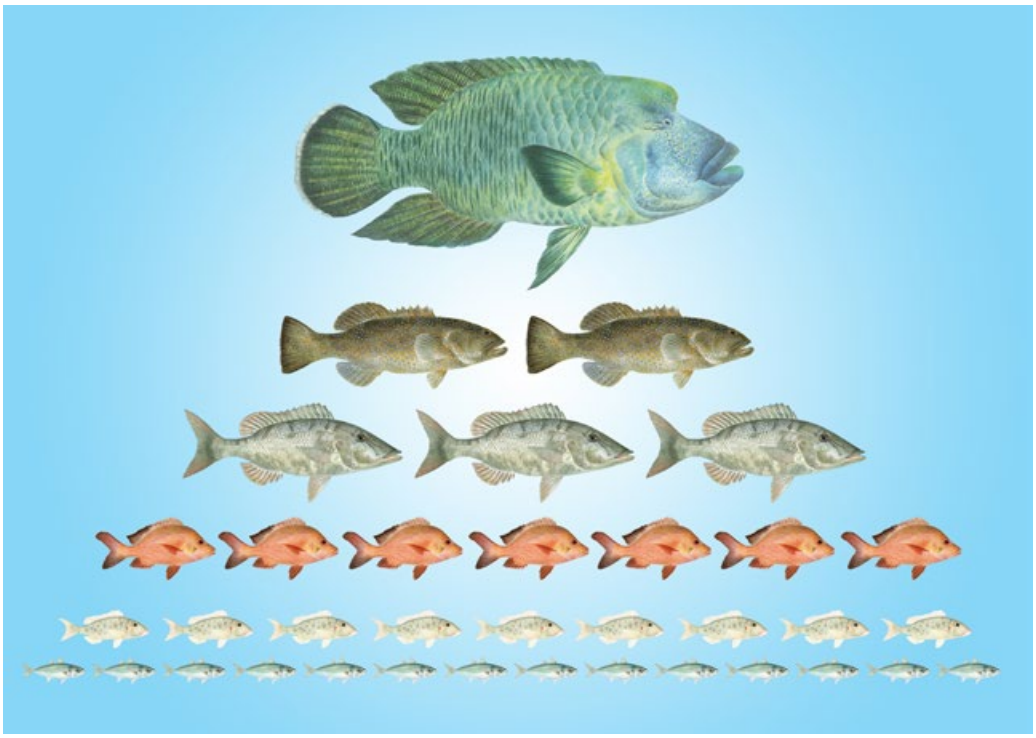

Figure 3. Fishing down the food web. (illustrations: Les Hata, © SPC and cChange)

Acknowledgements

The authors would like to thank the participants of the Koro Island management planning workshop for their contributions during the workshop and to the community of Tuatua village for hosting the workshop. We would also like to thank Dr Sangeeta Manghubhai for her final review of the article. Heartfelt thanks go to cChange for providing awareness materials such as videos, animations and illustrations that are simplified for local communities to understand. Thanks and gratitude are also owed to the David and Lucile Packard Foundation and the John D. and Catherine T. MacArthur Foundation for financial support.

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