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Digital Disease Ecologies: Encounter, Datafication and the Digital Geographies of One Health

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ABSTRACT

This paper examines intersecting digital, disease and more-than-human geographies to generate an analytical frame for interrogating how digital technologies configure disease emergence and multispecies health. The proliferation of digital tools in public health has spurred the development of 'digital health', a term encompassing the technologies that utilise digital media to manage illness and support well-being. Meanwhile, the rise of the One Health public health paradigm—and with it the idea that non-humans, humans and the environment form an interdependent system whose governance should be coordinated to secure positive health outcomes for all—has contributed to new technologies that monitor and manage health across species lines. Despite this ambition, much social scientific analysis has argued that digital health interventions are anthropocentric, only attending to non-humans insofar as they represent a risk to human health, with less consideration of how digital health technologies can cultivate understanding of and responsiveness to how pathogens, disease vectors, reservoirs and environments in specific contexts are implicated in and impacted by disease emergence. Through the case of Snake Awareness Rescue and Protection App (SARPA), a digital snake translocation and snakebite prevention mobile application in Kerala, India, this paper extends recent geographical 'digital ecologies' scholarship's concern for the digitisation of more-than-human worlds to digital health technology and disease control. To do this, it proposes the lens of 'digital disease ecologies': a way for geographers to analyse how diverse processes of digital encounter and datafication generate situated modes of understanding and acting upon disease. In so doing, it extends digital geographies' engagement with the more-than-human to consider how digitisation is consequential for multispecies health; contributes to health geography efforts to conceptualise how disease ecologies are shaped by the affordances of digital technology; and furthers geographical discussions of convivial human-non-human relations to question how digital technologies may facilitate coexistence.

1 | Introduction

The proliferation of digital tools in public health has spurred the emergence of 'digital health': a term capturing the varied technologies that utilise flows of data and digital media to manage illness and support well-being (Lupton 2022). Meanwhile, the rise of One Health as an influential public health paradigm—and with it the idea that animals, humans and the environment form an interdependent system that should be governed in a coordinated, interdisciplinary manner to secure positive health outcomes for all (Braverman 2022)—has contributed to the development of new technologies that seek to monitor and manage health across species lines (Lupton 2019). Despite this ambition, as Lupton (2022, 1–2) identifies, 'most definitions and interpretations of "digital health" are entirely human-centred', attending to non-humans through modes of

surveillance and datafication in so much as they represent a risk to human health, with less consideration of how digital health technologies can cultivate 'attentiveness and responsiveness' to how pathogens, disease vectors, reservoirs and environments in specific contexts are implicated in and impacted by disease.

Social science literature attending to digital health technologies has elucidated this anthropocentrism through critical studies of digital disease surveillance (Lupton 2022; Enns and Bersaglio 2024). These studies demonstrate how infrastructures of digital heat sensing, contact tracing mobile applications and digital epidemiology algorithms render the circulation of pathogenic microbes, disease vectors and reservoirs visible, reifying dominant imaginaries of pathogenic contagion regulated through bordered biosecurity (Hinchliffe et al. 2016; Enns and Bersaglio 2024). Such analyses of digital health echo critical accounts of One Health governance which argue that the paradigm's assumption of a singular health that can be rationally governed to secure an absolute state of human, animal and environmental well-being supports top-down public health programmes that fail to account for local worldviews (Hinchliffe 2015; Srinivasan et al. 2019), while remaining overwhelmingly anthropocentric, leaving little space for the needs of animals (Kamenshchikova et al. 2021).

Nevertheless, a recent current of digital geographies scholarship has supplemented critical accounts of digitisation's role in extending and consolidating hegemonic knowledge practices, institutions and extractive economies with more ambivalent accounts of how digital technologies may also enable more progressive environmental ethics and political potentials (Turnbull et al. 2023; Turnbull 2024). This digital ecologies scholarship channels more-than-human geographical concerns to consider how the digital may foster convivial human-non-human relations, analysing how digitisation does not '*inherently* disengage nor reconnect humans to nature' but rather 'foster[s] the potential for both, depending on socioeconomic, ecological, cultural, historical, and geographical context' (Turnbull et al. 2023, 2, emphasis in original).

Through the case of Snake Awareness Rescue and Protection App (SARPA), a mobile phone application used in Kerala, India, to coordinate the translocation of snakes that enter human homes, this paper extends this concern for the digitisation of more-than-human worlds to digital health technology and disease control. To do this, it supplements critical accounts of health technology with the lens of 'digital disease ecologies', a way for geographers to analyse how processes of digitisation generate situated modes of understanding and acting upon health and disease, with diverse consequences for more-than-human health. This analytical framework is consequential for three areas of geographical scholarship: it extends digital geographies' increasing engagement with the more-than-human to consider how digitisation is consequential for multispecies health; it contributes to efforts in health geography to conceptualise how disease ecologies are shaped by the place-based and spatial affordances of digital technology; and, more broadly, it furthers geographical discussions of convivial human–non-human relations to question how digital technologies may facilitate coexistence in the context of public health.

I begin by reviewing the existing geographical literature concerning critical approaches to disease ecology alongside digital ecologies analyses of environmental governance. I assemble these literatures to generate the analytical framework of 'digital disease ecologies': a way for geographers to examine how processes of digital encounter and datafication configure disease ecologies. Next, I outline the global health framing of snakebite envenomation (SBE) and the snake rescue mobile application, SARPA. I then recount this article's ethnographic methodology. Subsequently, I apply the digital disease ecologies lens to the case of SARPA, demonstrating how the platform mediates both experiential human-snake encounters and datafies information geographies of said encounters. This enables analysis of how SARPA engenders a preventative form of SBE governance, demonstrating how digital mediation is consequential for reconfiguring snakebite ecologies while folding concern for snake health into the biopolitical calculus of SBE governance.

2 | Digital Disease Ecologies: Mediating More-Than-One Health

The rise of digital technologies has been tracked by a disciplinary consolidation of medical geography into the field of health geography: a realignment aiming to explicitly analyse both the experiential (place-based) and structural (spatial) dimensions of health and disease (see: Kearns and Moon 2002). Yet despite developments in the assembly of medical and health geography perspectives, one may identify something of a retention of this prior schism in geographical analyses of the more-than-human dimensions of digital health. On one hand are place-based studies focussing on how experiential human–non-human encounters are mediated by digital health technologies, where sensing and communication technologies cultivate forms of attachment or distance to salutary or pathogenic non-humans (Zhou et al. 2020) or engender individualised health-seeking practices (Kenner 2016). On the other are spatial analyses of how digital technologies produce data to map or anticipate the circulation of pathogens, animals, commodities and people to prevent outbreaks (Roberts and Elbe 2017; Sparke and Anguelov 2020; Enns and Bersaglio 2024). As many digital health technologies both mediate patient experiences and generate data that is mobilised in broader programmes of public health (Grundy 2022), to deliver on the promise of a unified health geography, additional scholarship that analyses these technologies' place-based and spatial dimensions together is necessary to emphasise their role in pathogenesis.

The assembly of place-based and spatial analyses is expressed in the field of disease ecology, which recognises disease as complex, multifactorial and situated at the intersection of population, habitat and behaviours (May 1958; Meade 1986). More critical scholarship has supplemented this understanding with an emphasis on individual subjectivity and culture (Biehl and Petryna 2013), alongside the political ecological factors which generate the conditions for pathogen emergence and their responses (Brown and Kelly 2014; Wallace et al. 2015; Hinchliffe et al. 2016); render populations unequally vulnerable to disease (Farmer 1999; Kelly et al. 2019); and produce unequal access to treatment and medical care (Reid-Henry 2016; Sparke and Williams 2022). Critical disease ecologies perspectives depart

from notions of absolute states of health and illness, instead conceptualising how the intensities of immanent socio-ecological relations between animals, microbes, toxins, humans, and political, economic and societal institutions configure spatio-temporally situated 'disease situations', with associated programmes of action (Hinchliffe et al. 2016).

Within these ecological or 'configurational' accounts, 'health and disease become relative, not absolute, terms' (Cusworth and Lorimer 2024, 4), matters of contextual specificity engendered through the interplay of 'dynamic collectives of people, ideas and environments' (Hinchliffe et al. 2018, 2). Social scientists have mobilised this insight to productively trouble the 'one world-ist ontology' embedded within One Health paradigms—the assumption of an absolute state of health, or disease freedom, that can be rationally optimised through replicable programmes of biomedical intervention (Hinchliffe 2015; Braverman 2022). Disease ecology-informed 'more-than-One Health' accounts caution against such one-ness, which risks effacing local contingency and epistemic and ontological difference, seeking instead to offer accounts of situated 'healthy publics': collectives whose heterogenous composition and diverse problematisations of health issues attest 'that "health" is not the same thing for all humans and non-humans, everywhere in the world' (Kaiser-Grolimund et al. 2025, 2) but instead 'a process, an approximation, where the optimum may involve several sub-optima within the components' (Hinchliffe 2022, xxix). Health thus becomes spatialised, a 'matter of geographical specificity' (Hinchliffe 2022, xxx), necessitating enquiry into whose health—be it animal, microbial, human or environmental—comes to matter and be worked upon across patchy, locally-embedded disease ecologies. This in turn opens analysis of multispecies health governance beyond nominal One Health programmes to interventions that may problematise or nuance assumptions of one-ness, integration and hegemonic forms of public health (Braverman 2022).

As digital health technologies have proliferated across geographies, calls have emerged for 'careful further investigation' of how these 'information-rich' technologies expand and transform capacities to feel, know and act upon diverse disease ecologies (Hinchliffe et al. 2018, 3–6). Relatedly, digital geographers have turned their focus to the empirical specificities of how the spatialities of the quotidian digital are produced through conjunctions of 'specific objects, techniques, logics, processes, practices, and affects' (Ash et al. 2019, 3). Influential within these accounts is Leszcyzynski's (Leszczynski 2015) conceptualisation of spatial mediation. Eschewing notions of the virtual and analogue as discrete, pre-existing spheres brought together through the hybrid action of technological objects, Leszczynski (2015, 2019) extends post-structural spatial theory to propose an ontogenetic account of the digitisation of space. Here, spatiality is always-already mediated, emerging as 'the effect of the multiple, contingent, never complete comings-together of persons, technical presences (spatial media), and space/place' (Leszczynski 2015, 747). Digital media are not solely representative of the world but act materially to constitute both self and the world in what has been called the 'technological present' (Leszczynski 2015, 729). An account of digital mediation thus resists binary divisions of online/offline, allowing analysis of the digitised production of space, be it through the navigational capacities of mobile phones (Graham and Zook 2013), smart city monitoring for urban governance (Gabrys 2016; Rose 2022) or the 'aestheticisation' of place engendered by the circulation of social media imagery (Boy and Uitermark 2017).

Extending these ontogenetic accounts of the digital, a nascent body of literature within digital geographies has considered how processes of digital mediation implicate the more-than-human world. In line with the above relational approaches, this digital ecologies scholarship examines how 'digital entanglements' of diverse materials mediate digital environments, directing attention to their enrolment of and impact on non-human entities (Taffel 2021; Turnbull et al. 2023). Bringing necessary clarity to enquiry into the digital mediation of more-than-human worlds, digital ecologies suggests attention to two crucial processes of digitisation: (i) encounter, capturing how experiential human–non-human contact zones are digitally mediated by technologies—such as livestreamed wildlife webcams (Searle et al. 2023), virtual reality experiences (Wanneau 2025) and digital microbial imaging (Bradshaw 2024)—allowing differing or novel access to some more-than-human worlds at the expense of others, while generating affects, sense-making practices and modes of governance; and (ii) datafication, which, extending the insights of critical data studies (Iliadis and Russo 2016), considers how digital technologies sense and map environments by producing information that is operationalised as data within regimes of environmental governance (Turnbull et al. 2023).

Although disaggregated for analytical clarity, these processes of encounter and datafication act together to give rise to situated digital entanglements. This is exemplified by von Essen et al.'s (2023) study of wildlife surveillance technologies, where webcam monitoring of wild animals by the public allows previously inaccessible insight into non-human lives, giving rise to novel affects and ecological subjectivities in the human interlocutors of these digital encounters, while also generating data which is employed in conservation programmes involving biopolitical modes of care, culling and control. These diverse outcomes of digitisation attest to why advocates of digital ecologies analyses suggest an ambivalent approach to digitisation, acknowledging its potential to enable extractive industries, pathologise marginalised populations, and extend modes of surveillance, *as well as* harbouring potential to develop more convivial modes of living with more-than-human difference (Turnbull et al. 2023).

Despite the clear complementarities between disease ecologies and digital ecologies perspectives (relational ontology, attention to specific empirical cases, accounts of impacts on diverse publics), there has yet to be a systematic attempt to leverage their insights together to problematise the digital's role in enacting multispecies health. Uniting this scholarship, I propose digital disease ecologies as a frame to analyse the role of digital mediation in spatially configuring states of health and disease. Such an analytic follows the prior more-than-One Health accounts, approaching digital health technology ambivalently: not as an unproblematic good that virtuously elevates absolute health outcomes for humans, non-humans and their shared environments everywhere, nor as an actor that inherently intensifies existing power geometries of health inequality, but whose 'appropriate[ness], political[] just[ness], and biological[], social[], and

ecological[] legitima[cy]' is assessed within specific contexts (Hinchliffe 2022, xxxii). In this sense, it becomes necessary to enquire into how digitisation leads to disease ecologies being apprehended and configured divergently across geographies. This approach necessarily entails a biopolitical understanding of health (Hinchliffe et al. 2016), where health becomes a situated, multifactorial and more-than-human achievement; an outcome of the pathological interplay of more-than-human doings whose complexity does not lend itself to simple optimatisation. One Health thus 'becomes a more variable set of outcomes' for those entities constituting a particular digital disease ecology (Hinchliffe 2022, xxxii). Thus, digital disease ecologies necessarily contributes to more-than-One Health scholarship by accounting for how the locally-embedded mediating effects of digital encounter and datafication configure disease ecologies with diverse outcomes for human and non-human entities.

To demonstrate the utility of this frame, I analyse SARPA's mediation of human–snake relations through processes of digital encounter and datafication. This is not meant to exhaust all possible processes of digitisation, but instead to offer an analytically precise means of foregrounding the place-based and spatial affordances of a health technology's role in shaping disease ecologies. Thus, in turning to the empirical section of this paper, I merge disease and digital ecologies scholarship to demonstrate the utility of a digital disease ecologies framework in illuminating three key areas: (i) how a specific health technology mediates a situated disease ecology through processes of encounter and datafication; (ii) how this alters governance of a specific disease ecology; (iii) whose health comes to matter within a digital disease ecology.

3 | Snakebite Envenomation and Snakebite Awareness Rescue Protection App (SARPA)

On 9 June 2017, the World Health Organisation (WHO) added snakebite envenomation (SBE) to its list of Category A Neglected Tropical Diseases (NTDs) (Lancet 2017). A designation usually reserved for infectious diseases, snakebite's NTD status stemmed from a recognition of its burden on poor, rural populations in the Global South, where an estimated 100,000 people die annually of snakebite and a further 400,000 are permanently disabled (Chippaux 2017). Snakebite's 2017 NTD classification successfully raised the disease's profile in global health arenas, with the WHO's (2019) accompanying *Snakebite envenoming—A strategy for prevention and control* driving an uptick in research and funding for treatments for this pathology.

While SBE's reclassification has yielded successes in improving the quality and availability of antivenoms and identifying new treatments (Wellcome 2024), its focus on treatment has drawn into contrast the relative neglect of measures aimed at snakebite prevention. Fortner (2023) suggests that the overwhelming framing of SBE as a biomedical problem in global health has sidelined the structural issues (such as poor housing and labour standards) and socio-cultural factors (such as human–snake conflict) that mediate snakebite's burden. Fortner's (2023) concern grows out of SBE scholarship calling for 'transdisciplinary' approaches to the disease's governance (Gutiérrez et al. 2022), which aim to reimagine the problem–solution space of SBE governance by moving beyond a treatment-centred paradigm to attend to the political ecological relations that condition SBE's burden (de Ruiz Castañeda et al. 2022).

These drivers are present in India: the country with the highest recorded burden of SBE, experiencing an estimated 58,000 mortalities annually (Suraweera et al. 2020). Snakebite incidents typically involve India's 'Big Four', a group of snake species identified as the primary cause of serious envenomations: the common krait (*Bungarus caeruleus*), spectacled cobra (*Naja naja*), Russell's viper (*Daboia russelii*) and the saw-scaled viper (*Echis carinatus*) (Laxme et al. 2019). In Kerala, 104 snake species are found, including all of India's Big Four. Additionally, the region is inhabited by clinically significant species such as the king cobra (*Ophiophagus hannah*) and hump-nosed viper (*Hypnale hypnale*) (Suchithra et al. 2008).

In Kerala, snakes often enter human homes and workplaces. Due to the perceived danger of snake presence, snakes are often killed by humans or removed and translocated by individuals known as 'snake rescuers'. However, in 2019, SARPA, or as its founder calls it, the 'Uber for snake emergencies', was launched through a collaboration between the Kerala Forest Department, the Wildlife Trust of India, an IT company called Leopard Tech Labs and an NGO called Indiansnakes.org. SARPA enables members of the public to report a human–snake encounter, connecting users with snake rescuers who bag and translocate the snake while simultaneously generating data about where and when snakes are encountered.

Prior to SARPA's launch, snake translocation in Kerala was conducted in an unofficial capacity. Individual snake rescuers performed translocations for a small fee. Following several high-profile injuries to amateur rescuers, SARPA was launched alongside a set of snake rescue licensing laws. These regulations require snake rescuers to obtain a licence from the Kerala Forest Department, which is awarded on the condition that they use a standardised rescue technique called the 'Scientific Rescue Method' (SRM). Consequently, SARPA's launch was paired with a push to train and licence a volunteer cohort of rescuers.

This network of rescuers is made legible to the public through the SARPA mobile app. Alongside a field guide containing information on snakes and bite treatment advice, SARPA enables members of the public to upload a photo of an encountered snake. This GPS-tagged photo is sent to the nearest rescuer, who is directed to the scene to translocate the snake. The photo and location data from the translocation are aggregated in a centralised database, creating a dataset used by the Forest Department to inform snakebite prevention and conservation interventions. In a live bite event, SARPA notifies users of the nearest antivenom-stocking hospitals, supporting access to treatment in the critical first hour post-envenomation. Figure 1 shows SARPA's homepage, a rescue request, and a snake translocation attempt involving the Scientific Rescue Method.

SARPA thus represents a 'coded infrastructure': a network of diverse objects that are monitored and regulated in part by software (Kitchin and Dodge 2014). The capability of SARPA's software emerges through its 'technicity', or potentiality to act in relation to spatial configurations of snake rescuers, mobile phones, translocation equipment, servers, Kerala's varied rural

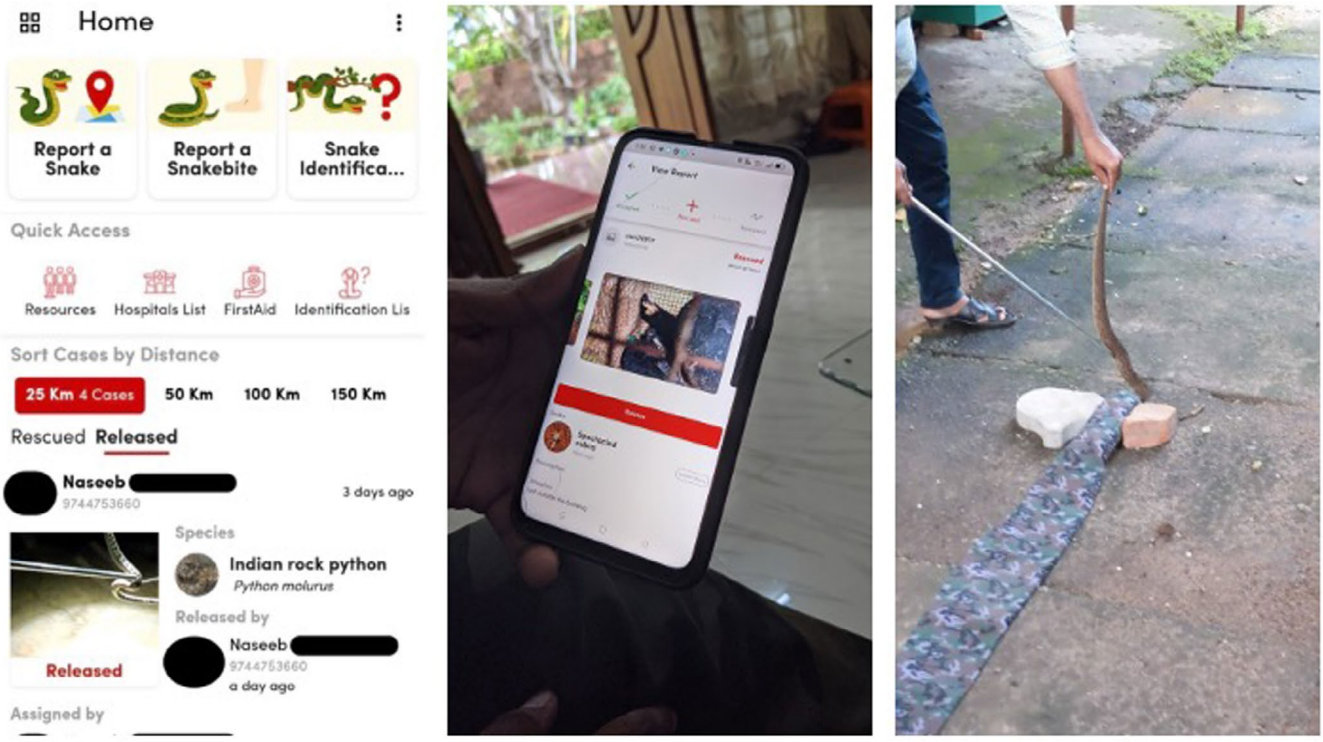

FIGURE 1 | SARPA's homepage, a rescue request and the Scientific Rescue Method (Credit: Indiansnakes.org and author).

and urban environments and snakes themselves (Kitchin and Dodge 2014). SARPA's translocation services are not wholly dependent on its digitised affordances, as 'offline' snake translocation services exist involving analogue telephone lines and word-of-mouth contact. Nevertheless, SARPA's coded infrastructure constitutes a broader coded assemblage of snakebite governance linking humans, snakes, antivenom production facilities, wildlife protection agencies and public health institutions to govern SBE (Ash et al. 2019).

4 | Methodology

This article draws on one month of participant observation in Kerala, India, with SARPA's designers, developers, and users in May 2022. This involved observing and participating in activities related to SARPA's day-to-day operations in four locations: Walayar State Forest Training Institute where rescuers are taught the SRM for translocating snakes; a snakebite awareness event in Thiruvananthapuram where officials demonstrated SARPA; and Kannur district and Kottayam district where I attended translocations with local rescuers. This was supplemented with 17 interviews with IT Professionals (Developers, Designers and Data Administrators, including SARPA's Founder), State Employees (Forest and Medical Officials, including SARPA's State Nodal Officer) and App Users (Snake Rescuers and public users). Ethical approval was obtained from the University of Oxford Central University Research Ethics Committee.

I now move to this article's empirical section, where I demonstrate the utility of a digital disease ecologies frame in analysing how SARPA configures snakebite ecologies. I begin by describing SARPA's mediation of human-snake encounters, before outlining its processes of datafication and mapping of snakebite geographies. Finally, I synthesise these insights to examine how they co-constitute situated ways of relating to and acting upon snakebite envenomation, with consequences for how snakebite is governed and whose health becomes a matter of concern in these measures.

5 | Encountering Ophidians

In this section, I address how human-snake encounters are mediated by processes of digitisation in efforts to render these events less harmful to both actors. Snakebites are not isolated incidents, but a risk negotiated in everyday life in Kerala. As I witnessed on rescue visits, snakes found their way into all manner of places, from clothes stores to coconut husks. A Forest Official explained: 'the habitats of snakes include towns, metropolitan areas, and forests. So, the habitat of snakes means everywhere' (03/06/22). Snakes are found all over Kerala and often occupy the same spaces as humans.

Snakebite situations emerge from human–ophidian encounters: eventful and risky moments of relation that provoke affects, drive responses and pose problems to interlocutors (Barua 2016). The problems posed by ophidian encounters were well recognised by SARPA's Founder:

> If someone finds a snake in their house, they are unsure if it is venomous, they are scared, they will feel like they have no choice but to kill the snake. This is when many bites occur, when a person was scared and

> tried to kill the snake. So really, this situation is no good for the snake or the humans – one is getting hurt.
>
> (31/05/22)

As this quote demonstrates, SARPA's designers and developers understood ophidian encounters to elicit feelings of uncertainty and fear. This affective condition is constitutive of harm to humans and snakes, motivating people to kill snakes and potentially enacting snakebite situations.

Nevertheless, human–snake cohabitation is not perceived as undesirable. As a senior Forest Official explained to me:

> Snakes are an integral part of human-inhabited areas also. They're integral for ecological balance, they keep rodent populations in check.
>
> (04/06/22)

Forest Officials expressed a 'probiotic' understanding of the value of snakes in managing life in urban areas (Lorimer 2020). Consequently, Forest Officials highlighted the need for endemic human–snake relations that allow for rodent control but whose pathogenicity does not tip into snakebite situations, posing a risk to public health (Hinchliffe et al. 2016).

However, human–snake encounters do not only provoke an affective response in humans, but also in snakes:

> Some snakes are very dramatic, they will run around all over the place, while others stay very still... Some are very irascible, if you get too close, they lash out, others not so, they will flee, they will go, and only bite if trodden on.
>
> (05/06/22)

Snakes express diverse responses to human encounters. Additionally, many officials emphasised how snakes' sensory capacities shape encounters:

> Snakes are very shy. If they are feeling the presence of human beings, sensing the vibration, they will try to hide somewhere. They know when they are near a human before a human knows, and they try very hard to avoid.
>
> (03/06/22)

Participants expressed a recognition of how snake lifeworlds are constitutive of SBE in Kerala: snakes are constantly sensing their environment, contributing to an encounter's affective atmosphere and influencing its outcome (Lorimer et al. 2019).

This analysis thus elucidates the multispecies effects and exchanges that were understood by SARPA's implementers to constitute snakebite governance. I proceed by exploring how SARPA's coded infrastructure intervenes in ophidian encounters to maintain less pathological human–snake relations through three digitised affordances: extended encounters, revealed rescues, and scientific snake handling.

5.1 | Extended Encounters

SARPA's core 'Report a Snake' function seeks to mediate the affective condition of encounters by dispelling uncertainty pertaining to a snake's venomousness. The feature allows users to spatially extend their ophidian encounter by sharing a photograph and short description of a snake with a rescuer. The photo arrives on the rescuer's device with a GPS location and the user's contact information, allowing the rescuer to share their estimated arrival time and pre-arrival advice. As SARPA's State Nodal Officer explained:

> If a snake is spotted, you can just have a click and upload – simple. If the photo is good and he sees it is non-venomous, he will call the person, tell them not to worry. And if it's venomous, he will say to be extra-careful, to stay far away, and he will come quickly.
>
> (03/06/22)

By digitising the snake, SARPA provides a means of rapidly making the encounter knowable to the rescuer prior to their physical arrival. Although the digitised animal is necessarily partial—a single image and brief description—it facilitates translation between distinct contexts, allowing the rescuer to assess the risk of the encounter, dispel the uncertainty of the 'analogue' snake's venomousness, and offer reassurance to the user. As a snake rescuer elaborated:

> It makes people feel more comfortable when I call them. They know someone is coming, and they know I am prepared [...] If, for example, I am told it is very large, I will bring someone for help, but if I see it is a rat snake I can say 'relax' to them.
>
> (02/06/22)

Pre-arrival insight into the encounter allows the rescuer to prepare themselves while also calming and advising the SARPA end-user. This enables early intervention into the encounter's affective condition, dispelling uncertainty and calming participants.

However, the digital animal's role in mediating the affective condition of human–snake encounters does not end here. User-generated snake images are subsequently added to SARPA's field guide for snake identification. The motivation for sharing these images with the public was explained by SARPA's State Nodal Officer:

> If there are good photographs of a variety of snakes, colourful snakes, very, very good-looking snakes, then people will be interested in how amazing their world is, how beautiful their world is, so it means [...] there is a motivation for conservation, and people will be not so motivated to kill snakes.
>
> (04/06/22)

Through circulation of the digital snake imagery, SARPA seeks to channel the animals' charismatic affordances to cultivate

an appreciation of snakes, encouraging individuals to respond to ophidian encounters less lethally. This is understood to attenuate the risk of a snakebite situation, as people will 'be not so motivated to kill snakes'. Through the circulation of snake imagery, the platform aims to mediate the affective condition of human–snake encounters, dispelling uncertainty to regulate risky behaviours that can tip encounters into snakebite situations. This theory of change is promissory, and a broader survey of attitudinal shifts is required to ascertain whether SARPA has achieved this objective. Nevertheless, I witnessed the more immediate implications of pre-contact by the rescuer, as telephone instructions to maintain a distance from snakes were often heeded and SARPA users explained how advance knowledge of the snake's non-venomousness made them comfortable to wait for a SARPA rescuer and not contact a neighbour to lethally dispose of the snake. SARPA thus intervenes in the affective dimensions of SBE's disease ecology through pre-arrival insight into encounters.

5.2 | Revealed Rescues

SARPA's 2020 launch entailed a state-wide push to licence a cohort of volunteer snake rescuers. As outlined by SARPA's Lead Developer, this stemmed from the recognition that:

> The snake rescuer is the core part of the system. If there are no snake rescuers, the application isn't going to work.
>
> (31/05/22)

In response to this issue, SARPA's implementers sought to create a 'critical mass' of rescuers across the state to respond 'flexibly' and in 'real-time' to the pervasiveness of human-snake encounters (07/06/22). Facebook, WhatsApp, and the press were used to recruit rescuers so, in the words of SARPA's Kannur District Coordinator:

> Now, if there's a call, within 5 minutes SARPA finds the nearest rescuer from around that area and they can go.
>
> (05/06/22)

This widespread mobilisation of volunteer rescuers is made legible to SARPA users through two in-app features: a list of licensed rescuers and a feed showing completed translocations from within a 5-kilometre radius. SARPA's Founder described the rationale for the rescue updates:

> It's creating a pre-emptive awareness that there are snakes and that they can be rescued. [...] It's strengthening the faith in the system. They will see that there are rescuers active. If they see a snake, they will already feel safer, less scared, because they are aware that someone is there to help.
>
> (10/06/22)

By visibilising the novel rescue infrastructure and illustrating the safe resolution of nearby encounters, SARPA seeks to generate 'pre-emptive awareness' that, upon finding a snake, wherever one is located, rescue services are accessible. This was seen to discourage users from handling or harming a snake themselves.

SARPA thus constitutes an 'affective infrastructure' (Kemmer et al. 2019): by providing rescue services and visualising these operations, SARPA makes its infrastructural presence felt in ophidian encounters. This infrastructural presence conditions the encounter to encourage users to contact rescuers instead of taking matters into their own hands, making snakebite situations less likely to arise. These affects and material outcomes then 'fold back into the infrastructure' (Kemmer et al. 2019, 32) in the form of the digitised encounter that is presented to other users as testament to the service's efficacy.

5.3 | Scientific Snake Handling

SARPA does not only seek to mediate human experiences of ophidian encounters but also recognises snakes as 'animal subjects': embodied, sensing beings that affect and are affected by the world (Lorimer et al. 2019). As described prior, SARPA was introduced alongside legislation in Kerala that mandated a snake translocation technique dubbed the 'Scientific Rescue Method' (SRM). SRM involves a snakehook, a cotton bag and a PVC pipe. During a rescue, the bag is wrapped around the pipe to create an 'artificial hole'. The snake is then supported by the snakehook while the rescuer lifts its tail, maintaining a safe distance between the snake's head and the rescuer's body. The snake's eyes are aligned with the artificial hole so that it slithers into the bag, 'thinking it is a safe hideout' (04/06/22). The rescuer blocks the bag with the hook before knotting it. The snake is then translocated, and a photo is taken on release.

Snake rescuers are trained in SRM, and further information on the technique is shared in the SARPA app. When asked about the benefits of SRM versus alternative forms of rescue such as freehand capture or net-assisted trapping (common techniques prior to the application's introduction), SARPA's State Nodal Officer explained:

> Catching and gripping the snake anywhere apart from very lightly on its tail will definitely damage its vertebrae and the snake will feel very stressed, making the bite positivity likely... So instead, we model this method on the snake's anatomy... we are just lifting the tail and we are supporting with a hook – it will feel very free, and it will feel very safe in that support.
>
> (04/06/22)

SRM seeks to account for the snake's anatomy by safely supporting its body, making the snake comfortable and less likely to bite. The method draws on ethological insights:

> It's based on the basic behaviour of snakes... Seeing the hole itself the snake will enter. There is no compulsion and the snake has a very good feeling

> of safety. It thinks it's a safe hideout: 'I'm just going inside the bag'. So, no stress for the snake, no risk for the rescuer.
>
> (03/06/22)

SRM accounts for the snake's preference for dark, enclosed spaces, so as not to compel movement. This is seen to not stress the snake, managing the encounter's intensity by reducing the risk of harm. While the degree to which the snake remains unstressed during the rescue was unclear—I witnessed several snakes strike the artificial hole instead of slipping in—the above quote demonstrates how the object-target of SARPA's mediation extends to the felt intensities of snakes.

As a coded infrastructure, SARPA employs material practices such as SRM to manage the affective condition of humans and snakes through ethologically and anatomically informed techniques. Information on how to perform these techniques is made digitally available through the SARPA app. Additionally, by provisioning information about the 'correct' translocation technique to the public through the app, SARPA's implementers explained that they intended to develop an expectation of standard rescue practice within the Kerala public. This was bolstered by initiatives encouraging the public to report rescuers practicing noncompliant forms of translocation or 'ransoming' (demanding money prior to snake removal). In so doing, SARPA extends regimes of surveillance across snake rescuers, specifying appropriate ways of interacting with snakes.

Through the standardisation and widespread application of these techniques, SARPA addresses the pervasiveness of human-snake encounters, shaping the felt intensities and capacities of snakes and humans to stave off snakebites and prevent harm to snakes. However, outcomes for snakes should also be investigated. While popularly referred to as a snake rescue app, SARPA ultimately facilitates the translocation of snakes. Although there is some disagreement, studies of the impacts of translocation on snakes suggest that the practice, although more palatable to humans, may be, in the case of snakes, 'killing them softly' (Cornelis et al. 2021). Translocation risks leaving snakes stressed from capture and disorientated within their new environment, potentially resulting in the animals struggling to find food and water, being more easily predated and susceptible to disease or straying into human-occupied spaces. Additionally, due to the heterogeneity of snake species, Forest Officials emphasised the need for skilled rescuers who could appropriately adapt scientific translocation techniques to different snake behaviour while locating suitable areas for release.

SARPA's State Nodal Officer and Founder recognised these issues yet explained that SARPA's implementation was not a 'quick-fix solution' to snake conservation, but part of a broader effort to generate snake tolerance among the public. Snake rescuers are required to attend a one-day training session before they receive accreditation. Here, they are taught about basic snake biology, how to differentiate and handle distinct species, and the ecological value of snakes. The Forest Department requests that rescuers share this information with the public during rescue visits to support them in identifying venomous species and to cultivate appreciation of the value of snake presence in predating rodents. Additionally, rescuers are trained to encourage, but not insist, that, particularly in the case of non-venomous species, members of the public agree to a snake's release as close to the capture site as possible. As SARPA's State Nodal Officer explained:

> The first time it might be that they allow the rescuer to take it down the road. Then, it might be over the garden wall. And finally, once they understand it is not harmful, they might let the snake just leave from the garden on its own,
>
> (03/06/22)

SARPA's mediation of human–snake encounter thus co-mingles negative and affirmative relationalities. The act of 'scientific rescue', or translocation, while optimised for snake anatomy, carries with it the risk of harm to snakes, thus prioritising the well-being of human interlocutors through the affordance of removal the digital service offers to human users. Nevertheless, translocation remains a promissory act, one that aims to achieve a more favourable outcome than the certain death that lethal removal entails. Furthermore, the mobilisation of snake rescuers and the transmission of expertise to Kerala's publics aims to create broader acceptance of overlapping human and snake geographies, enabling short-range translocation of venomous species or phasing out the need for translocation in the case of non-venomous species.

SARPA's SRM practices mediate human-snake encounters by both facilitating the exclusion of snakes from human-occupied spaces while also pursuing a promissory state of human–snake coexistence through the dissemination of herpetological expertise. These measures—through the shorter-term replacement of lethal or more harmful forms of snake translocation and longer term efforts to encourage snake tolerance—embrace a preventative governance of SBE, which specifies snake wellbeing as a matter of concern. Questions of human-animal coexistence and shared health outcomes thus enter the traditionally human-centric, treatment-orientated public health imaginary of SBE. Nevertheless, these measures do not represent a wholly virtuous optimisation of human and snake health, as human safety and preferences for ophidian proximity remain prioritised above optimal outcomes for snakes. Such 'competing interests' and 'uncertain outcomes' are characteristic of the 'compromises and adaptations to the conditions of life' which mark the realities of One Health governance (Hinchliffe 2022, xxxiv).

This section demonstrates how SARPA's digitised affordances mediate the affective condition of human-snake encounters. By analysing how SARPA extends encounters, reveals rescues and scientifically handles snakes, I demonstrate how SARPA not only configures human–snake relations in Kerala but also contributes to a distinctive SBE ecology—one which embraces a preventative approach to disease governance that specifies the lives of snakes as a matter of concern. Through the digital mediation of human–snake encounters, a distinctive disease ecology emerges, one where snake translocation becomes a widespread, digitally coordinated practice, mediating ophidian encounters to be less affectively charged in the hope that this will reduce lethal acts of snake removal and reduce the need for snake

translocation. SARPA thus reconfigures SBE disease ecologies, opening snakebite to preventative modes of governance, mediating affective exchanges in human-snake encounters and enacting snake well-being as a (secondary) matter of concern.

6 | Datafying Encounters

SARPA's digitisation of encounters does not solely mediate human-snake interactions but also produces information that is operationalised as data. In a rescue request, an image of the snake, its GPS location, timestamp, and a brief description of the surrounding environment are uploaded to SARPA's servers. The information is checked for authenticity and the snake species is identified by SARPA's Lead Biologist before being aggregated in a database. Within SARPA's internal dashboard—available only to Forest Department Officials—this dataset is visualised on a digital map which can be filtered and zoomed to explore the spatio-temporal distribution of ophidian encounters in Kerala.

While this datafication allows the platform's implementers to monitor SARPA's day-to-day operations, the Forest Department also sees it as remedying a deficit in reliable snakebite data. As SARPA's State Nodal Officer explained:

> This kind of a data collection will get us a lot of information about snakes and snakebites: the ecology of snakes, the epidemiology of snakebites, and the seasonal variation in snake rescues, everything which we are struggling to find data for at the moment. And the data collection is continuous, so we will identify any changes too.
>
> (03/06/22)

SARPA's datafication provides an adaptive means of grasping the distribution of ophidian encounters in Kerala. The rescue data is supplemented with data from Kerala's hospitals concerning antivenom availability and records of locations where snakebite awareness programmes have taken place. SARPA's implementers have mobilised these data streams to model and predict where and when the risk of snakebite is most acute. For example, if data show an area to have a high frequency of encounters, poor quality housing and limited antivenom supply, the team will anticipate a higher likelihood of snakebite situations.

This practice remains inherently probabilistic, focused on how incidence of human-snake encounter in particular regions and during particular seasonal shifts (such as monsoon) may indicate a need for enhanced SBE governance. As is common in practices of digitised, data-informed mapping (Chandler 2018), there is awareness that data collected by SARPA provides only a partial view of snakebite in Kerala. As described by SARPA's Founder:

> We are collecting very basic information about the snake. We could collect lots more useful information: what is the type of house, whether it was electric or fire, whether there is cow dung kept, whether it is near fields [...] One, we don't have the bandwidth to accept that information. And two [...]. the user should be able to do everything in 15 seconds, because they do not have time to fill out all that information. [...] The data works for us now, but in the future we will add more features maybe, if we find we need specific information.
>
> (10/06/22)

SARPA's datafication is recognised by the platform's implementers to offer a limited view of SBE's political ecological drivers, wherein key elements are omitted due to technical constraints and usability concerns. SARPA thus pursues an 'iterative and processual attempt to visualise a particular set of relationships' (Chandler 2018, 35), where the app's software may be tweaked in future to collect additional data which supplements this partial view. Consequently, SARPA's datafication of ophidian encounters produces 'just good enough' data (Gabrys et al. 2016); recognised for its partiality while remaining useful in understanding where snakebite hotspots may arise.

SARPA's datafication and mapping of human-snake encounters informs state-level governance initiatives across Kerala. This approach was outlined by a senior Forest Official:

> We can see, with the map, where the frequency of snake-human cohabitations is more. So, we have to be very, very concentrated on that area, to train more rescuers, make sure antivenom is available, let people know what to do to be safe.
>
> (02/06/22)

Although partial and probabilistic, as human-snake encounter does not necessarily lead to bites, SARPA's mapping facilitates the prioritisation of activities to address specific SBE drivers, including the paucity of snake rescuers and antivenom in particular regions. Most prominently, this data has enabled the Forest Department to identify several towns where encounters with venomous snakes were significantly more common and which had been historically underserved by licensed rescuers and engagement initiatives. This led the Forest Department to prioritise snakebite prevention initiatives for target groups including school age students, teachers, Kudumbashree women empowerment network coordinators, agricultural employers and agricultural labourers.

Additionally, SARPA's mapping of ophidian encounters has allowed the Kerala Forest Department to identify several regions where hump-nosed viper encounters are common. At the time of fieldwork, no antivenom manufacturers produced hump-nosed antivenom due to perceived insufficient demand. Nevertheless, analysis of SARPA's encounter data has led the Forest Department to estimate the number of antivenom vials required for areas where human–viper cohabitation is common. Assisted by this data, the Forest Department has entered talks with the Evolutionary Venom Lab, Bangalore, and a pharmaceutical manufacturer to produce this antivenom, in the hope it will be distributed to hospitals in affected areas.

This ability to better estimate the demand for antivenom has sparked efforts by the Kerala Forest Department to intervene in what Quet (2025) calls the 'extractive loop' of antivenom production. Although relatively low intensity, antivenom production requires the periodic extraction of wild snakes from their habitats to milk the venom used to produce antivenom serums (Quet 2025). As this practice disrupts wild snake populations and inflicts stress on individual snakes, its reduction has been identified as a priority for snake welfare in the antivenom industry (Vargas et al. 2021). The Kerala Forest Department has begun to utilise SARPA's encounter data with local hospitals in service of antivenom procurement, a measure they believe will not only ensure better access to treatments for humans but also reduce antivenom wastage, thus reducing upstream demand for venom harvesting and downstream cost-saving. Increased coordination and information exchange across diverse societal actors to achieve positive multispecies health outcomes is typical of the promise of One Health, and yet in this case and many others, remains a challenging proposition unfulfilled (Craddock and Hinchliffe 2015). Nevertheless, it is true that SARPA's datafication has mediated the extractive loop of antivenom production, engendering channels of communication between the Forest Department, hospitals, antivenom manufacturers and snake rescue operations that previously did not exist, and thus opening a potential pathway for snake welfare within SBE's disease ecology.

SARPA has also facilitated species-specific programmes of snake surveillance and governance. As SARPA's Lead Designer explained, data generated through SARPA revealed an increasing number of Indian pythons in urban centres in Kerala. This was seen as an unusual change in ophidian geographies, as Forest Officials remained unsure of how urban environments were supporting these large snakes. Nevertheless, Forest Officials explained that they had begun to respond by providing resources for urban snake rescuers outlining practices through which the public could better protect domestic animals from these snakes. These methods again seek to promote tolerance of pythons and reduce lethal removal initiatives.

Nevertheless, these modes of biopolitical governance directed towards urban pythons betray an important consideration of the information geographies inherent within SARPA. Due to the platform's datafication of geographies of human-snake encounter, ophidian health is only made sensible through its relation to human spaces, emerging as the object-target of governance within SARPA's logic of snakebite prevention. SARPA's mediation of snakebite disease ecologies casts a 'data shadow' (Shelton et al. 2014), as processes of datafication render human–snake encounters as 'informational magnets' (Graham et al. 2015), leading to those snakes most commonly found in human-dominated spaces, such as rat snakes, kraits, spectacled cobras and pythons, becoming more visible in datafied regimes of surveillance and conservation, while other species are underrepresented. This is despite SARPA's implementers typically describing the application in terms of its benefits for 'snakes' in general.

The challenges of ecological monitoring of snakes due to their cryptic behaviour are well documented (Willson et al. 2011). Herpetologists have suggested that much promise lies in smartphones and social media as means of extending regimes of snake conservation (Durso et al. 2021). Attention to SARPA's information geographies demonstrates how multispecies health is made visible and governed according to localised contingencies and the limitations of SARPA's infrastructural affordances. While SARPA's mediation does enable programmes of surveillance and species-specific conservation initiatives for some snakes, others are ultimately left out of the picture. One thus sees how, by adapting regimes of datafication and surveillance to the local contingencies of SARPA's snake translocation programme, regimes of visibility are created for some species of snakes while others remain out of view.

By datafying and mapping ophidian encounters, SARPA aims to prevent snakebites, protect snakes and enable access to appropriate treatment. In turn, this configures SBE ecologies by facilitating targeted intervention on specific geographies of human–snake encounter, intermediating the extractive loop of venom production and enacting biopolitical logics of snake surveillance and conservation action on those species made visible through processes of datafication.

7 | Conclusion

Digital disease ecologies is a lens for geographers to analyse how digital technologies mediate situated spatial configurations of disease through processes of encounter and datafication with consequences for human and non-human health. This approach contributes to three key areas of geographical scholarship: firstly, it intervenes in health geography's project of consolidating the spatial and place-based dimensions of illness and health by attending to how digitised processes of encounter and datafication are constitutive of dynamic disease ecologies and contextually-specific programmes of action upon disease situations. Secondly, it develops digital geography's growing interest in the digital mediation of more-than-human worlds by foregrounding its implications for the health and well-being of multispecies bodies. Thirdly, and at a broader level, it adds to geographical debates concerning conviviality between humans and non-humans, illustrating how digital technologies may act as mediators of shared life and interspecies coexistence.

Applying the digital disease ecologies lens to the case of SARPA, a digital intervention from a snakebite-endemic context, demonstrates how processes of digitised encounter and datafication intervene in the human–snake relations that condition SBE's emergence while mediating the provision of antivenom and Kerala's wider snakebite ecology. This digitised preventative model of snakebite governance supplements treatment-centric models while specifying the health of (some) species of snakes as a matter of concern, thus departing from an anthropocentric understanding of the harms of SBE. This analysis contributes to calls in critical health geography to consider 'more-than-One Health' enactments of health 'tied to the geographical argument that borders between species are borderlands where many things happen beyond contamination and infection' (Braverman 2022, 6). Instead of solely focusing on remedying the harms inflicted on humans by snakes, SARPA's digital mediation and mapping seeks to foster a less harmful human-snake entanglement, one that is less likely to tip into snakebite situations with attendant harms to

snakes and humans. This is not a wholly virtuous process of human-snake health optimisation, as the compromises of the scientific rescue method and SARPA's data shadows show, yet it represents an example of how attention to digital health technologies may reveal those situated understandings of disease situations, compromises, and adaptations made in efforts to extend concern for non-human well-being within digitised public health programmes.

Further research expanding the digital disease ecologies perspective may consider how uneven infrastructural coverage creates digital divides in what is made a target of digital disease governance and whose health comes to matter (Nost and Goldstein 2022); how 'glitches' or frictions in the operation of digital technologies may be constitutive of minor engagements with the mediation of human–pathogen, vector and reservoir relations (Leszczynski and Elwood 2022, 362; Searle et al. 2023); and how digital technologies interact with culturally specific health-seeking beliefs and practices. These approaches should be expanded to a wider range of digital health cases, including artificial intelligence (Maalsen 2025). Nevertheless, in their recent work assessing the field of digital ecologies, citing climate crisis, mass extinction and biodiversity collapse, Searle (2024, 1) ask, 'what role might digital media play in securing liveable futures across species lines?' In light of the risk of zoonotic spill-over, inevitable conditions of the endemic co-presence of humans, vectors and pathogens, and the salience of One Health within public health, how pathogenicity can be managed to achieve more liveable multispecies futures represents a crucial area of enquiry aligned with digital ecologies' normative ambitions (Hinchliffe 2022). Digital disease ecologies provide one means of assessing the possibilities and pitfalls of diverse digital health technologies in achieving this promise.

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