

## Suspected chikungunya outbreak in Klungkung, Bali: Environmental and behavioral risk factors

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### ABSTRACT

Chikungunya outbreaks in communities with no prior recorded transmission history remain poorly studied in Indonesia, where delayed case detection and low community health literacy present distinct epidemiological challenges. This study investigated a suspected chikungunya extraordinary event in Banjar Jumpai Kangin, Desa Jumpai, Kabupaten Klungkung, Bali, between April and May 2025, with the aim of describing the epidemiological characteristics of the outbreak and identifying the environmental and behavioral risk factors associated with transmission. A case-control design was employed, with data collected through structured interviews, direct environmental observation, and secondary data review. A total of 36 suspected cases were identified, peaking at 8 cases on 8 May 2025, with the majority being female (58.3%) and aged 5 to 14 years (33.3%). All cases presented with fever (100%), followed by arthralgia (91.7%) and rash (83.3%). Bivariate analysis identified four significant risk factors, including the absence of routine water storage container draining ( $p$  less than 0.001), the absence of mosquito nest eradication practices ( $p = 0.046$ ), the presence of mosquito larvae in the household ( $p = 0.032$ ), and the lack of personal protective behavior against mosquito bites ( $p = 0.018$ ). Community knowledge of chikungunya was uniformly poor across both case and control groups. Delayed case reporting substantially prolonged the period before any public health response was initiated. These findings underscore the need for proactive community-based surveillance in areas with no prior chikungunya history, and support policy interventions targeting household vector control practices and health literacy as the primary levers for outbreak prevention.

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## INTRODUCTION

Chikungunya is a vector-borne infectious disease caused by the chikungunya virus (CHIKV), an alphavirus of the family *Togaviridae* (Silva & Dermody, 2017), transmitted to humans through the bite of infected *Aedes aegypti* and *Aedes albopictus* mosquitoes (Frezgi et al., 2025). Following an incubation period of 3 to 7 days, the disease typically presents with sudden-onset fever and debilitating joint pain, accompanied by other manifestations such as headache, myalgia, skin rash, and joint swelling (Santiago et al., 2025). Most patients recover within a week, although a proportion experience persistent arthralgia lasting for months, and severe neurological complications including transient paralysis have been reported in rare cases. Although chikungunya is self-limiting with a case fatality rate approaching zero, its capacity to generate explosive outbreaks within a short period places it among the most epidemiologically significant arboviral diseases in tropical regions (Kementerian Kesehatan Republik Indonesia, 2017).

In Indonesia, CHIKV is a re-emerging pathogen that has disappeared and re-emerged repeatedly over the decades (Baskoro Tunggal Satoto & Alvira Pascawati, 2022). Official reports documented the first chikungunya cases in Samarinda, East Kalimantan, in 1973 (Harapan et al., 2019), followed by at least 24 probable outbreaks across Indonesia between 2001 and 2003 after a two-decade hiatus (Khongwichit et al., 2021). Subsequently, nationwide transmission escalated, with annual reported cases rising from around 3,000 to 83,000 and 52,000 cases in 2009 and 2010, respectively (Stubbs et al., 2020). Despite this burden, CHIKV remains frequently overlooked as a cause of acute febrile illness due to limited diagnostic capacity and its clinical overlap with dengue, which complicates timely case identification (Arif et al., 2020). Epidemiologically, nearly all regions of Indonesia carry the potential for chikungunya outbreaks, given the ubiquitous presence of the *Aedes* vector, high population density, and widespread human mobility (Kementerian Kesehatan RI, 2020). Bali presents a particular concern in this regard, as chikungunya infections have been reported sporadically across the island, including a laboratory-confirmed outbreak in Buleleng in 2015–2016 and a notable surge in cases in 2010 linked to high tourist mobility and labor flow (Sari et al., 2017; Yoshikawa & Kusriastuti, 2013).

Several prior studies have examined behavioral and environmental risk factors for chikungunya in Indonesia, though their findings have not always been consistent. An investigation of a 2010 outbreak in West Kalimantan identified failure to eliminate mosquito breeding sites as the dominant behavioral risk factor (aOR 3.51) (Sitepu et al., 2020), while a 2013 case-control study in Serdang Bedagai found that the lack of personal protective measures (OR 3.5) and the habit of hanging worn clothing indoors (OR 2.6) were equally or more prominent (Sitepu & Depari, 2019). The 2024 Gunungkidul investigation, by contrast, found larvae presence and rainwater collection to be the primary drivers, with no significant independent association attributed to general PSN practices (Handika et al., 2025). A systematic review of mitigation measures for CHIKV similarly concluded that no single behavioral strategy demonstrates consistently superior protective effects across outbreak settings (Hierlihy et al., 2019). These inconsistencies suggest that the behavioral determinants of CHIKV transmission are context-dependent and cannot be generalized without community-specific investigation.

A related gap concerns the role of community health knowledge as an upstream determinant of preventive behavior. Studies have shown that low disease awareness often coexists with poor protective practices, yet few outbreak investigations in Indonesia have examined knowledge explicitly within an analytic framework connecting awareness, behavior, and transmission risk (Zerfu et al., 2024). Most prior investigations were also conducted in settings with some documented history of chikungunya exposure, leaving communities with no prior recorded transmission largely understudied. In such settings, the absence of collective disease experience may amplify both transmission risk and detection delay, as residents and healthcare workers are less likely to recognize and report cases promptly.

This study draws on an environmental and behavioral epidemiology framework, positioning CHIKV transmission as the product of three interacting domains, namely host susceptibility shaped by community knowledge and individual preventive behavior, the household environment determining local vector density, and the surveillance context governing detection timeliness. Within this framework, poor community knowledge of chikungunya is hypothesized to function as an upstream factor that elevates transmission risk indirectly through its effect on breeding site management, mosquito nest eradication, and personal protection practices. This study therefore hypothesizes that household-level behavioral variables will be significantly associated with chikungunya occurrence, and that community health literacy regarding chikungunya will be uniformly low, consistent with the absence of prior disease exposure in the area.

This study investigated a suspected chikungunya outbreak in Banjar Jumpai Kangin, Desa Jumpai, Kabupaten Klungkung, Bali, which was reported to health authorities only on 15 May 2025 despite evidence that transmission had begun nearly three weeks earlier. The study aimed to confirm the occurrence of the outbreak, describe its epidemiological characteristics based on person, place, and time variables, and identify the environmental and behavioral risk factors associated with transmission.

## RESEARCH METHOD

This study employed a case-control design embedded within a descriptive epidemiological investigation of a chikungunya outbreak (Irshad Roghani et al., 2024). The descriptive component characterized the distribution of cases according to person, place, and time variables, while the analytic component examined the association between selected environmental and behavioral exposures and the occurrence of chikungunya illness. A case-control design was selected given its suitability for outbreak investigations with small sample sizes where the primary objective is to identify risk factors driving transmission within a defined population (Arif et al., 2020; Yalew Assefa et al., 2020).

The study population consisted of all 576 residents of Banjar Jumpai Kangin. A suspected case was defined as any resident presenting with at least three clinical features consistent with the national case definition issued by the Ministry of Health of Indonesia, including sudden-onset high fever up to 40°C, arthralgia in large joints, myalgia, maculopapular rash, headache, chills, conjunctival redness, nausea, and vomiting (Baskoro Tunggul Satoto & Alvira Pascawati, 2022). The scientific validity of this clinical case definition in the Indonesian context rests on its derivation from the characteristic triad of CHIKV infection, namely fever, arthralgia, and rash, which has demonstrated adequate sensitivity for suspected case classification in outbreak settings where laboratory confirmation is unavailable (Kementerian Kesehatan Republik Indonesia, 2017). Laboratory confirmation through serological or RT-PCR testing was not conducted in this investigation, as the majority of patients had already recovered at the time of the field visit and declined blood sampling. This is consistent with the Ministry of Health guidelines, which explicitly permit outbreak classification based on clinical and epidemiological criteria alone when specimens cannot be obtained (Kementerian Kesehatan Republik Indonesia, 2017). Data were collected using a structured questionnaire that had been pre-tested on a small group of community members prior to the main data collection to assess clarity and item comprehension, and subsequently refined based on the results of that pre-test.

Controls were defined as residents of Banjar Jumpai Kangin living adjacent to or directly across from a confirmed case, with no history of fever or symptoms consistent with chikungunya during the outbreak period. This neighborhood-based selection strategy was chosen to minimize selection bias by ensuring that cases and controls shared comparable residential environments and vector exposure conditions, thereby isolating behavioral rather than locational differences as the primary source of variation between groups. Regarding sample sufficiency, 36 cases with a 1:1

case-to-control ratio yielded 72 total participants. For a case-control study with an expected odds ratio of approximately 3.0 for the primary risk factor, a two-sided alpha of 0.05, and an estimated exposure prevalence of 50% among controls, this sample size provides adequate power for bivariate analysis in a defined community outbreak investigation, consistent with methodological guidance for small-population outbreak settings (Arif et al., 2020; Yalew Assefa et al., 2020).

Participants were identified through snowball sampling, beginning with the index case and progressively tracing subsequent cases through social and geographic networks within the community (Kennedy-Shaffer et al., 2021). Data were collected through structured interviews, direct environmental observation, and review of secondary data from the local public health center and the Klungkung District Health Office (Paul et al., 2020). Bivariate analysis using chi-square tests was performed to assess the association between each risk factor and chikungunya occurrence, with odds ratios and 95% confidence intervals calculated to measure association strength, and a p-value below 0.05 considered statistically significant. Variables achieving statistical significance in the bivariate stage were subsequently entered into a multivariate logistic regression model to identify independent predictors of illness and to control for potential confounding. Confounding was addressed by including all bivariate-significant variables simultaneously in the regression model, allowing the independent contribution of each factor to be estimated while holding other variables constant. Two potential sources of bias were acknowledged. Recall bias may have been introduced through retrospective self-reporting of behavioral practices, as participants who became ill might differentially recall their exposures relative to those who remained healthy. Information bias was partially mitigated by supplementing interview responses with direct environmental observation of household conditions.

## RESULTS AND DISCUSSIONS

### Results

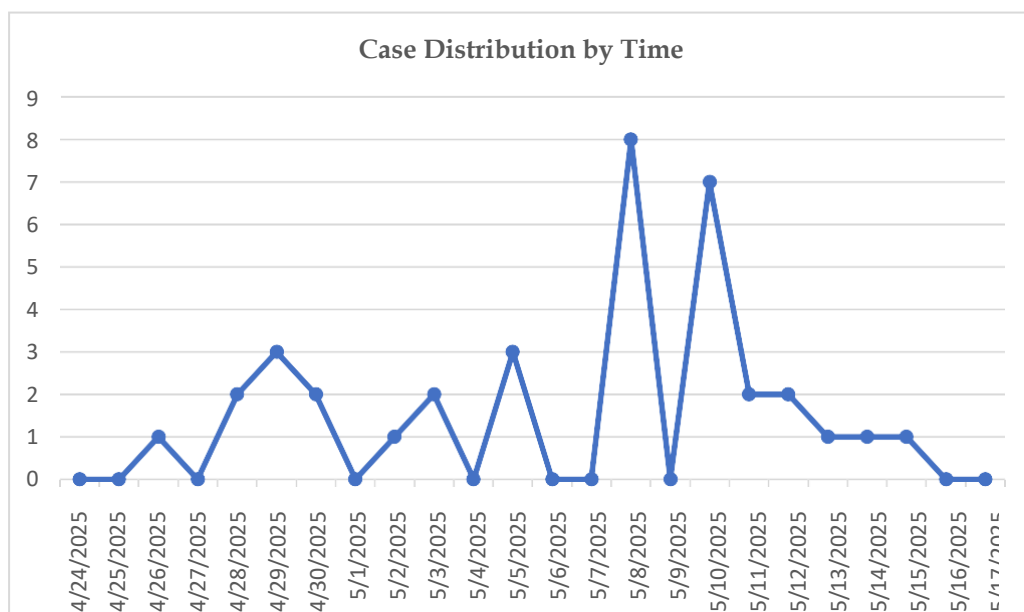
#### Temporal Distribution of Cases

Field investigation revealed that the first suspected chikungunya case in Banjar Jumpai Kangin was recorded on 26 April 2025, involving a single individual presenting with symptoms consistent with chikungunya infection. Transmission continued progressively through 15 May 2025, yielding a total of 36 suspected cases. At the time of investigation, a number of patients had already recovered, and most had sought treatment at private medical practices rather than the local public health center, which explains the absence of chikungunya records at Puskesmas Klungkung I prior to the formal report.

The outbreak was classified as a suspected chikungunya KLB on two grounds. First, surveillance data from the preceding five years indicated no prior chikungunya cases in the area. Second, more than one individual with clinically compatible symptoms was identified within the same village, satisfying the operational definition stipulated in the Guidelines for Investigation and Response to Extraordinary Events of Communicable Diseases issued by the Ministry of Health in 2020, which states that a KLB is declared when more than one chikungunya case is identified in a village or subdistrict with no prior recorded history of the disease (Kementerian Kesehatan RI, 2020). As no laboratory examination was conducted, case classification was based exclusively on clinical signs and symptoms.

As shown in Figure 1, the index case was identified on 26 April 2025, after which transmission spread progressively within the same residential environment, reaching a peak of 8 cases on 8 May 2025. Despite ongoing transmission, no mosquito control measures had been carried out prior to the investigation, as health authorities were only notified on 15 May 2025 and did not deploy a field team until 17 May 2025, by which date no new cases were identified. The epidemic curve displays a propagated pattern characterized by multiple successive peaks, consistent with ongoing vector-mediated transmission rather than a single common-source

exposure event. The interval between successive peaks in the curve approximates the extrinsic incubation period of CHIKV in *Aedes aegypti*, which under tropical temperature conditions of 28–30°C has been documented at approximately 2 to 4 days, providing a biologically plausible basis for the observed inter-peak spacing (Frezgi et al., 2025; Santiago et al., 2025). Figure 1 presents the epidemic curve as a bar chart displaying the daily number of new cases across the outbreak period, which more precisely captures the propagated transmission pattern than a cumulative curve would allow.



**Figure 1.** Case distribution by time of the chikungunya KLB in Banjar Jumpai Kangin, Desa Jumpai, Kabupaten Klungkung, Late April to May 2025

### Clinical Presentation

All 36 suspected cases presented with fever (100%), followed by arthralgia in 33 cases (91.7%), skin rash in 30 cases (83.3%), myalgia in 9 cases (25.0%), and headache in 4 cases (11.1%). No cases presented with hemorrhagic signs. The distribution of clinical symptoms is summarized in Table 1.

**Table 1.** Distribution of Cases by Clinical Symptoms of Chikungunya in Banjar Jumpai Kangin, May 2025

Symptom	n	%
Fever	36	100.0
Arthralgia (joint pain)	33	91.7
Rash	30	83.3
Headache	4	11.1
Myalgia (muscle pain)	9	25.0
Hemorrhagic signs	0	0.0

### Distribution of Cases by Person

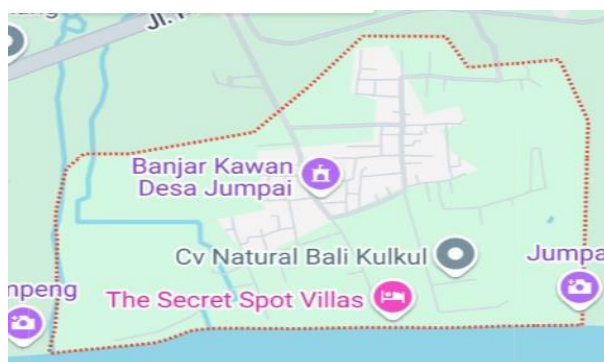
Of the 36 suspected cases, 21 were female (58.3%) and 15 were male (41.7%). The 5–14 year age group represented the largest proportion at 33.3%, followed by the 45–64 year group (25.0%), the 25–44 year group (19.4%), the 15–24 year group (13.9%), the over-65 group (5.6%), and the 1–4 year group (2.8%). The demographic distribution is presented in Table 2.

**Table 2.** Distribution of suspected chikungunya cases by person in Banjar Jumpai Kangin, May 2025.

Characteristic	Frequency	Percentage
<b>Age Group</b>		
1-4 years	1	2.8%
5-14 years	12	33.3%
15-24 years	5	13.9%
25-44 years	7	19.4%
45-64 years	9	25.0%
>65 years	2	5.6%
<b>Sex</b>		
Male	15	41.7%
Female	21	58.3%

**Geographic Distribution of Cases**

All 36 suspected cases were concentrated within Banjar Jumpai Kangin, Kabupaten Klungkung. Desa Jumpai borders the Bypass Ida Bagus Mantra corridor, a major arterial road facilitating high population mobility and freight movement, which increases the potential for communicable disease to spread across areas through human movement. The overall attack rate was 3.24 per 100 population and the case fatality rate was 0, consistent with the self-limiting nature of chikungunya infection. The spatial distribution of cases is illustrated in Figure 2.



**Figure 2.** Map showing the location of the chikungunya outbreak in Jumpai Village

**Risk Factor Analysis**

Assessment of respondents' knowledge revealed poor understanding across all four domains assessed. As shown in Table 3, more than half of all respondents answered incorrectly on items covering the definition of chikungunya (58.3%), its causative agent (52.8%), its mode of transmission (58.3%), and its clinical symptoms (55.6%). Because this low-knowledge pattern was distributed similarly across both case and control groups, chi-square analysis of each knowledge item against case or control status did not yield statistically significant differences. The uniform distribution of poor knowledge across both groups means that knowledge in this community functioned as a pervasive background characteristic rather than a discriminating risk factor at the individual level, and its influence on transmission is therefore more appropriately interpreted as a community-level upstream determinant that shaped the overall behavioral environment in which the outbreak occurred, consistent with the conceptual framework described in this study.

**Table 3.** Distribution of risk factors based on respondents' knowledge level

Knowledge Domain	Incorrect Responses	%
Definition of chikungunya	42	58.3%
Causative agent of chikungunya	38	52.8%
Mode of transmission	42	58.3%
Clinical symptoms of chikungunya	40	55.6%

Bivariate analysis results are presented in Table 4. Of the eight variables assessed, four showed statistically significant associations with chikungunya occurrence. Routine draining of water storage containers was significantly protective against illness ( $p < 0.001$ ; OR 0.160, 95% CI 0.053–0.479). The presence of mosquito larvae in or around the household was significantly associated with increased illness risk ( $p = 0.032$ ; OR 0.352, 95% CI 0.134–0.926). The absence of mosquito nest eradication practice or PSN was associated with a 2.8-fold higher likelihood of illness ( $p = 0.046$ ; OR 2.800, 95% CI 1.005–7.800). The habit of avoiding mosquito bites through protective measures such as mosquito nets, repellent lotions, or long-sleeved clothing was similarly protective ( $p = 0.018$ ; OR 0.318, 95% CI 0.121–0.834). The remaining four variables, including burying or managing used household items, use of closed water containers, cleanliness of waste disposal areas, and adequacy of household wastewater management, did not demonstrate statistically significant associations with chikungunya occurrence in this investigation.

**Table 4.** Results of bivariate analysis of environmental and behavioral risk factors in Banjar Jumpai Kangin, Kabupaten Klungkung, 2025

Risk Factor	Cases n (%)	Controls n (%)	Total	p-value	OR (95% CI)
Draining water storage containers					
No	16 (44.4%)	30 (83.3%)	46	<0.001	0.160 (0.053–0.479)
Yes	20 (55.6%)	6 (16.7%)	26		
Burying or managing used items					
No	16 (44.4%)	10 (27.8%)	26	0.141	2.080 (0.779–5.552)
Yes	20 (55.6%)	26 (72.2%)	46		
Mosquito nest eradication (PSN)					
No	28 (77.8%)	20 (55.6%)	48	0.046	2.800 (1.005–7.800)
Yes	8 (22.2%)	16 (44.4%)	24		
Presence of mosquito larvae					
No	11 (30.6%)	20 (55.6%)	31	0.032	0.352 (0.134–0.926)
Yes	25 (69.4%)	16 (44.4%)	41		
Use of closed water containers					
No	18 (50.0%)	20 (55.6%)	38	0.637	0.800 (0.317–2.021)
Yes	18 (50.0%)	16 (44.4%)	34		
Waste disposal cleanliness					
Unclean	18 (50.0%)	12 (33.3%)	30	0.151	2.000 (0.772–5.184)
Clean	18 (50.0%)	24 (66.7%)	42		
Wastewater management					
Poor	17 (47.2%)	14 (38.9%)	31	0.475	1.406 (0.551–3.587)
Good	19 (52.8%)	22 (61.1%)	41		
Habit of avoiding mosquito bites					
No	14 (38.9%)	24 (66.7%)	38	0.018	0.318 (0.121–0.834)
Yes	22 (61.1%)	12 (33.3%)	34		

## Discussion

The occurrence of suspected chikungunya cases in Banjar Jumpai Kangin represents a disease event that had never previously been recorded in this community. Data from the Klungkung District Health Office confirmed that no chikungunya cases had been reported over the preceding five years, from 2020 to 2025. A total of 36 cases were formally documented on 17 May 2025 based on the results of interview-based field investigation and survey. The index case in Banjar Jumpai Kangin was not identified directly by the Puskesmas or the Klungkung District Health Office. It was only on 15 May 2025 that a community report reached health authorities, stating that residents of Banjar Jumpai Kangin had been falling ill with fever in succession for two weeks prior. Following a field investigation conducted on 17 May 2025, it was established that illness had first begun in a student resident of Banjar Jumpai Kangin on 26 April 2025, and had continued to spread within a single alleyway until 15 May 2025.

Based on interviews conducted with Puskesmas staff, the delayed detection occurred because no prior report had been submitted by community members or the local banjar leader. The majority of residents in Banjar Jumpai Kangin sought treatment at private medical practices, which meant that no chikungunya case records were available at the public health center. This pattern reflects a broader challenge in Indonesia, where CHIKV remains frequently underdiagnosed as a cause of acute febrile illness due to limited diagnostic testing capacity and its clinical overlap with dengue virus infection, both of which hinder timely and accurate case identification (Arif et al., 2020). The clinical features experienced by patients included fever, joint pain, muscle pain, and a maculopapular rash. Blood sampling for laboratory confirmation was not carried out, as patients declined the procedure on the grounds that they had already recovered. The outbreak was therefore classified as a suspected chikungunya KLB, consistent with the Ministry of Health guidelines issued in 2017, which define a suspected case as an individual presenting with sudden high fever accompanied by at least two supporting manifestations such as joint pain, skin rash, myalgia, headache, chills, conjunctival redness, nausea, vomiting, or cervical lymphadenopathy (Kementerian Kesehatan Republik Indonesia, 2017).

Descriptive analysis showed that the majority of cases were female, accounting for 58.3% of the total. A review examining sex as a biological variable in chikungunya found that female sex has been associated with heightened symptomatic response and greater likelihood of chronic arthralgia following CHIKV infection, attributed in part to immunological differences between sexes that influence host susceptibility and clinical presentation (Taylor & Rayner, 2023). The predominance of female cases in this outbreak may also reflect behavioral patterns related to time spent at home during peak biting hours of *Aedes* mosquitoes. Regarding age distribution, the 5–14 year age group constituted the largest proportion of cases at 33.3%. Studies of chikungunya epidemiology have consistently observed that recurrent outbreaks preferentially affect the youngest age groups, as long-lasting immunity following prior infection protects older individuals while immunologically naive younger cohorts remain susceptible (Gérardin et al., 2008). This pattern is particularly relevant in a community with no prior recorded chikungunya history, where the entire population would lack pre-existing immunity across all age groups.

Univariate analysis of respondents' knowledge regarding chikungunya revealed that awareness was generally low across the study population, indicating a need for strengthened community health education through counseling, information media, or community-based interventions to improve basic knowledge of chikungunya as part of broader vector-borne disease prevention and control efforts. Assessment of behavioral risk factors showed that 63.9% of respondents had never drained their water storage containers, while only 47.2% practiced personal protective measures against mosquito bites such as the use of bed nets, repellent lotion, or long-sleeved clothing. Although 65.3% reported performing PSN regularly and 63.9% practiced the management of used household items, a significant proportion of the community had not adopted the full range of preventive behaviors. These findings indicate that community preventive behavior against chikungunya was not yet fully optimal, reflecting a need for more comprehensive and consistent health promotion. Inconsistent prevention practices of this kind have the potential to sustain vector breeding conditions and increase transmission risk within the community.

Bivariate analysis of the association between water storage container management and chikungunya occurrence yielded a statistically significant result ( $p < 0.001$ ; OR 0.160, 95% CI 0.053–0.479), indicating that individuals who routinely drained their containers were substantially less likely to experience illness. The biological rationale for this finding lies in the life cycle of *Aedes aegypti*, which undergoes complete metamorphosis from egg to larva to adult in approximately 7 to 10 days under favorable conditions (Depkes RI, 2005). Containers left undrained for longer than one week therefore serve as productive breeding sites, directly increasing local vector density and transmission risk. The habit of burying or managing used household items was not significantly associated with chikungunya occurrence ( $p = 0.141$ ). This contrasts with the findings of the

chikungunya outbreak investigation in Serdang Bedagai, which found that failure to routinely eliminate mosquito breeding sites, including proper disposal of used items, was a significant risk factor for chikungunya infection (OR 2.8, 95% CI 1.38–5.73) (Sitepu & Depari, 2019). The absence of a significant association in this study is likely explained by the nature of solid waste in this community, which consisted predominantly of food and beverage packaging rather than larger containers capable of accumulating standing water.

Of the 72 respondents, 43 were found to have mosquito larvae present in their households, while 29 were larvae-free. The presence of mosquito larvae was significantly associated with chikungunya occurrence ( $p = 0.032$ ; OR 0.352, 95% CI 0.134–0.926), with larvae-free households demonstrating approximately 65% protection against the probability of illness compared to those with larvae. The entomological investigation of case households in the Serdang Bedagai chikungunya outbreak confirmed a parallel pattern, with House Index, Container Index, and Breteau Index values all substantially exceeding the national standard of below 5%, confirming that high larval density directly sustains community transmission (Sitepu & Depari, 2019). A case-control study in Borobudur Subdistrict, Magelang further demonstrated that households with mosquito larvae were 4.8 times more likely to experience dengue infection (95% CI 1.61–14.30), reinforcing that household-level larval presence is a consistent risk factor for *Aedes*-transmitted arboviral disease (Ismail et al., 2024).

Analysis of the association between container type and chikungunya occurrence showed that respondents using open containers accounted for 52.8% of the total, compared to 47.2% who used closed containers. However, bivariate analysis yielded no statistically significant association between container type and illness occurrence ( $p = 0.637$ ; OR 0.800, 95% CI 0.317–2.021), suggesting a trend toward protection with closed containers that did not reach statistical significance. This finding is consistent with entomological evidence suggesting that *Aedes aegypti* breeding is influenced more strongly by drainage frequency and container management behavior than by physical container type alone, as mosquitoes can exploit a wide variety of water-holding containers regardless of whether they are open or partially covered when not properly maintained (Prasad et al., 2023). A study in Maros Regency, South Sulawesi, Indonesia similarly found that the relationship between container type and larval presence depended heavily on drainage frequency and indoor location rather than open or closed status alone, reinforcing that behavioral practices surrounding container management are the primary determinant of breeding site productivity (Agus Nurjana et al., 2023).

The absence of significant associations for four of the eight variables assessed, specifically the management of used household items, use of closed water containers, waste disposal cleanliness, and wastewater management, warrants methodological consideration. One plausible explanation is limited statistical power: with 36 cases and 36 controls, the study was adequately powered to detect odds ratios of approximately 3.0 or higher, but associations of more modest magnitude may have fallen below the threshold of detection. A second explanation is that in this particular community, the distribution of these exposures was insufficiently different between cases and controls to generate a detectable signal, possibly because both groups practiced similarly suboptimal behaviors in these domains. Third, some of these variables, particularly waste disposal cleanliness and wastewater management, may represent more distal environmental conditions whose effects on transmission are mediated entirely through proximal variables such as larval presence, which was already captured separately in the analysis. The non-significant findings therefore do not indicate that these variables are irrelevant to chikungunya transmission in general, but rather that they were not differentiating risk factors within this specific community at the time of investigation.

PSN practice was significantly associated with chikungunya occurrence ( $p = 0.046$ ; OR 2.800, 95% CI 1.005–7.800), with 77.8% of case group respondents not practicing PSN compared to 55.6% in the control group, indicating that those not engaging in mosquito nest eradication were

2.8 times more likely to experience illness. A case-control study in Kotawaringin Timur, Indonesia found that households not engaging in PSN Plus behaviors were significantly more likely to experience dengue infection, with several components including recycling used items and installing window screens demonstrating significant protective associations (Hartati et al., 2025). The biological mechanism underlying this association reflects the dependence of *Aedes aegypti* on clean standing water for breeding, meaning that routine PSN practice reduces local vector population density and consequently lowers the probability of transmission. These findings reinforce the importance of sustained community campaigns and behavioral interventions to promote PSN as a cornerstone of effective chikungunya prevention (Kementerian Kesehatan Republik Indonesia, 2020).

### Limitations and Bias

Several sources of bias should be acknowledged in interpreting the findings of this study. Recall bias represents the primary concern, as behavioral exposures were assessed retrospectively through self-report, and case participants who experienced illness may have differentially recalled or reported their practices compared to controls who remained healthy, potentially overstating the association between certain behaviors and illness. This limitation is inherent to the case-control design and could not be fully eliminated, though direct environmental observation of household conditions was used to partially corroborate self-reported data on container management and larval presence. Selection bias was addressed through neighborhood-based control selection, but snowball sampling of cases introduces the possibility that socially connected individuals, who may share similar behavioral profiles, were overrepresented in the case group. Information bias may also have arisen from the absence of laboratory confirmation, as clinical misclassification of non-chikungunya febrile illnesses as cases cannot be excluded; however, the symptom profile across the 36 cases was highly consistent with CHIKV infection and met the national clinical case definition. Finally, the relatively small sample size limits the precision of the odds ratio estimates, particularly for variables whose confidence intervals approached the boundary of significance, and the findings should be interpreted with these constraints in mind.

## CONCLUSION

This investigation confirmed the occurrence of a suspected chikungunya extraordinary event in Banjar Jumpai Kangin, Desa Jumpai, Kabupaten Klungkung, involving 36 cases between 26 April and 15 May 2025, with an attack rate of 3.24 per 100 population and a case fatality rate of zero. Four behavioral and environmental factors were significantly associated with chikungunya occurrence, including the absence of routine water storage container draining, the absence of mosquito nest eradication practices, the presence of mosquito larvae in the household, and the lack of personal protective behavior against mosquito bites, indicating that transmission was driven by modifiable household-level conditions amenable to public health intervention. Effective prevention requires the active participation of community members alongside institutional support from the Puskesmas and district health office, through sustained PSN practices based on the 3M Plus principle, prompt case reporting, strengthened community-based surveillance, and regular health education. These findings should be interpreted within the context of several limitations, including the absence of laboratory confirmation, the retrospective self-report nature of behavioral data, and the relatively small sample size, all of which constrain the precision of the estimates and preclude causal inference. In terms of generalizability, the results are most directly applicable to similarly structured communities in Bali and comparable settings across Indonesia where chikungunya has no prior recorded history, *Aedes* vector density is high, and health literacy regarding the disease remains low. The specific behavioral risk factors identified here may not generalize to communities with different waste management infrastructure or prior chikungunya exposure, and future studies incorporating laboratory confirmation, standardized entomological indices such as the

House Index and Breteau Index, and multisite designs would strengthen the external validity of these findings.

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