

# Sustainable drainage to address Zika in favelas, Brazil: community perspectives

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# Sustainable Drainage to address Zika and lack of drainage in favelas, Brazil: community perspectives

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## Abstract

The 2015 Zika virus outbreak in Brazil established that neonate microcephaly was related to maternal infection by the virus during pregnancy, the highest densities of which occurred in the northeast and southeast of Brazil, the country's most populated areas. These areas are typically associated with informal settlements or favelas which lack effective water management, sanitation and drainage, hence providing suitable breeding environments for the *Aedes aegypti* mosquito, the Zika virus vector. This paper reports on a novel study of community perceptions around the potential for Sustainable Drainage Systems to provide a means of reducing areas for the mosquito to breed, and hence reduce Zika infections in favelas. Interviews were carried out with key external stakeholders working with favelas and members of the favela community. Poor management of water supply, drainage and solid waste were clearly emphasised by participants illustrating gaps in current research connecting these areas. Participants proposed that only a holistic approach could address sanitation issues, hence the distribution of Zika-carrying mosquitos, subsequent infections and microcephaly. An approach was therefore needed taking account of the environment as a whole, increasing public awareness of sanitation and environmental health, improving sanitation infrastructure and providing adequate systems for solid waste management.

ARTICLE TYPE: Paper

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## Introduction

As is common the world over, those who reside in informal settlements live with the results of lack of land tenure, in comparison with those in the "formal" areas of the city. In general, informal settlements lack facilities and infrastructure to manage solid waste and dispose of greywater, as well as manage stormwater and subsequent flooding and the potential consequences in terms of proliferation of disease vectors such as mosquitoes, leading to impacts on human health and quality of life (Armitage, 2011). Whilst there are many terms which

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refer to an informal settlement, in Brazil the specific name for these settlements is “favela”, named after the tree around which the first of these settlements was located in the late 19th century (Cath, 2012). Hence, the term favela will be used hereinafter.

Charlesworth et al., 2022 reported on the results of a study which examined conditions in favelas in the northeast and southeast of Brazil which may have been implicated in the outbreak of the Zika virus (ZIKV) and of some babies being born with microcephaly (abnormally small heads; Vissoci et al. 2018) during 2015-16. Observations and in-depth interviews provided information that supported the view that on-street disposal of greywater (i.e. water produced by households not including toilet water) and lack of drainage of stormwater due to heavy rain provided conditions in which the ZIKV-carrying mosquito (mainly *Aedes aegypti*) could breed in close proximity to households. Whilst it would appear that the ZIKV epidemic may be under control, nonetheless, the mosquito is responsible for companion viruses chikungunya, dengue and yellow fever (Kraemer et al., 2019) and it is highly likely that ZIKV will return in the future. Thus, a long-term perspective is required if the kind of outbreak of ZIKV experienced during 2015-16 is to be prevented in the future. However, few studies investigate the infrequent water supply in favelas, the problems disposing of solid waste and socio-economic factors hindering investment in sanitation. In fact, the issue of solid waste is yet to be fully integrated into multi-disciplinary studies investigating mosquito-vectors in informal settlements (Wilson et al., 2019). Such information is necessary in order to formulate future strategies to address these issues.

This paper reports on a British Council Newton Institutional Links Award between the UK and Brazil. Based in Rio de Janeiro, the focus was on the relationship between the favelas, provision of sanitation, greywater management and the prevalence of ZIKV. Data from the Brazilian government suggests that about 95% of the city of Rio de Janeiro is connected to the water supply system (Kelman 2015). However, the statistics do not account for the fact that the supply is unreliable, particularly in relation to Rio’s 2990 favelas (Charlesworth et al., 2022). According to Britto et al. 2018 and Dias et al. 2018 regular issues are encountered with supplies of piped water, as well as seasonal issues faced during times of drought or high demand. These problems cause health concerns in Rio’s favelas due to the incorrect storage of water in open containers on roofs and inside homes, deterioration of water quality due to long-term storage, the introduction of disease pathogens, cross-contamination and the presence of disease vectors including mosquitoes (Lowe et al. 2018). These issues are common in informal settlements in general worldwide as well as in other cities in Brazil (Katukiza et al. 2012; Justo and Kenney 2016).

The issue of disposal of solid waste and its place in the proliferation of disease vectors has not been fully investigated from the point of view of informal settlements in general, or favelas specifically (Armitage 2011; Wilson, et al., 2019). Brazil’s National Guidelines for Basic Sanitation, established by Law n° 14026 (2020) (Vieira Coelho, 2020) explicitly states the requirement for the collection and disposal of solid waste. However, as stated above, due to their “informal” status, favelas do not have access to these services. With no alternative, waste accumulates in the street and, depending on the topography of the site, may flow downslope of settlements and into rivers, leading to contamination of the environment, accumulation of polluted runoff and the provision of suitable places for disease vectors to breed in collected water (Charlesworth et al., 2022). In studies by Mezue et al., 2020 and Charlesworth et al., 2016 of the potential to use SuDS in informal settlements in Lagos, Nigeria, solid waste was identified as blocking what drainage infrastructure there was. These issues are common in cities with informal settlements globally and are subsequently implicated in the proliferation of water-borne and water-related disease (Annenberg Foundation 2017).

In terms of issues around governance, whilst Brazil is not unique, nonetheless there are substantial problems associated with crime and the persistence of drug trafficking that make addressing sanitation in some favelas difficult. This has also meant that the government has been reluctant to invest in improving infrastructure in favelas, exacerbated by police raids and the presence of the Pacifying Police Unit

(UPP) since 2008. In addition, internal and external stakeholders have negative perceptions of one another, which prevents them from working together (Adler et al. 2017). The larger-scale infrastructure projects such as the “Informal Settlements Urbanization-Growth Acceleration Program” (PAC-UAP; Lima-Silva and Loureiro, 2020) have largely been abandoned in favour of smaller public health initiatives such as the training of those living in favelas as community health workers, avoiding the necessity of government representatives visiting the favelas to engage with the community.

There is some discussion in the literature around these issues, however there is little if any that connect these barriers with water management in favelas. This paper therefore has two aims:

- 1) To ascertain the feasibility of using SuDS in a favela environment to address the lack of drainage infrastructure, and
- 2) To investigate whether the favela community would engage with a SuDS approach to reduce the incidence of ZIKV infections.

In addressing these issues, the United Nations Sustainable Development Goals (UNSDGs) that are relevant include: 3 Good Health and Wellbeing; 6 Clean Water and Sanitation; 11 Sustainable Cities and Communities; 16 Peace, Justice and Strong Institutions and 17 Partnerships for the Goals.

## 2. Methodology

### 2.1 Site selection

Charlesworth et al., 2022 gave details of the decision making for selecting Rio de Janeiro as a study site based on the high numbers of confirmed ZIKV cases during the 2015-16 outbreak in Brazil; there were 1.67 million notified cases of which 2.5% were pregnant women (de Oliveira et al., 2017). Of those reported cases of infection, 1950 resulted in babies being born with microcephaly. Figure 1 shows the location of Rio de Janeiro State, Metropolitan Area and Municipality (the City).

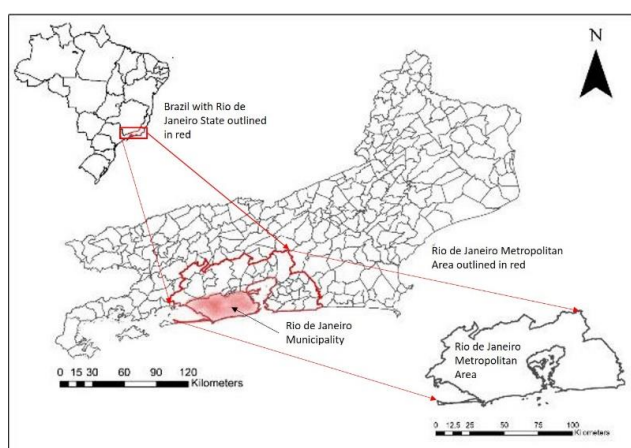


Figure 1 The locations of Rio de Janeiro State, Metropolitan Area and Municipality (City).

### 2.2 Data collection

A total of 16 in-depth interviews were carried out individually with both stakeholders and members of the favela community in Rio de Janeiro, using 2 complementary schedules; one was focused on external stakeholders (including academics based in local universities, government representatives, NGOs and public sector organisations which were involved in projects based in the favelas) and the second focused on members of the favela community. It is acknowledged that there were fewer favela residents than other stakeholders (Table 1), this arose due to limitations on access to the favelas during the field visit because of concerns over safety at the time. However, some of the stakeholders, such as the health workers, also worked in the favelas and so were able to share their experiences and views.

Questions were asked from the perspectives of the four main a priori thematic areas the research focused on: Governance, Favelas, ZIKV and Sanitation, to identify the potential for different stakeholders to implement SuDS and the challenges that recommended SuDS interventions would have to address. A list of the principal interview questions are given in Table 2 with further details of the interviewees given in Charlesworth et al., 2022 and summarised in Table 1.

Table 1 Participant background and number taking part.

| Participant background | Number of participants |
|------------------------|------------------------|
| Social Sciences        | 3                      |
| Natural Sciences       | 7                      |
| Health workers         | 2                      |
| Government employees   | 2                      |
| Favela community       | 2                      |

The individual interviews were semi-structured whereby the order of the questions was provisional, allowing for flexibility in allowing participants to lead any conversation based on their own expertise and background, enabling the development of additional lines of discussion during the interview. The sample size of the in-depth interviews allowed participants to describe their actions, opinions and life-experiences and was chosen to collect these rather than conducting larger, less detailed samples for statistical analysis (McDowell, 2010).

The difference between the two interview schedules was in the type of open-ended questions used which were designed to produce short or more comprehensive responses, a technique used in order to ensure that language challenges could be addressed and ensure the participants were comfortable (Hay 2005). Thus, members of the favela community were encouraged to give relatively short responses related to their everyday life whereas the questions for external stakeholders were fairly broad and open-ended. Interviews with both groups of participants enabled understanding of key factors around government policy as well as potential barriers to the provision of water management infrastructure in favelas. A translator was always present during the interviews in order to ensure that any language challenges for interviewer, interviewee and translator could be addressed and that there was accurate understanding on both sides.

### 2.3 Template Analysis of interview returns

Charlesworth et al., 2022 gave details of the Template Analysis carried out to analyse the results of the interviews. This process identified significant recurring themes or revealed noteworthy insights, which were assigned a shorthand description and a code. Once the list of codes was produced, a hierarchical weighting was applied to those codes that occurred most often; identified themes were then sorted into categories and sub-categories (King 2004). Each of the transcripts was re-reviewed in order to ensure that the original coding re-emerged – preventing bias or subjectivity related to themes (Cope 2010). Some additional coding hierarchies were created, and a final outputs theme produced into which any previously uncategorised codes were placed.

Table 2 Questions used for in-depth interviews with A.) external stakeholders and B.) members of the favela community

|  |
|--|
| <b>A. External stakeholder interview questions</b>   |
| Do you know of any government policies or initiatives that support the provision of better infrastructure in favelas?  |
| Do you know of any NGOs or University projects working on upgrading activities in favelas?   |
| Do you know of any favela communities where formal drainage exists?  |
| If yes, how effective is it?   |
| In your interactions with favela communities, have you noticed any community initiatives to improve sanitation?  |
| Where there are areas with inadequate drainage and/ or water management infrastructure, do you think that there would be a reduction in mosquito populations and the transmission of vector-borne disease if approaches were used to reduce the presence of surface water? |
| <b>B. Favela community members interview questions</b>   |
| Is the community flooded? In the past or present?  |
| Is the origin of the flood from the river or from rain?  |
| Are there specific areas which flood in the community?   |
| When is rainfall the heaviest during the year?   |
| Where is household greywater (from cooking, cleaning, bathing) disposed of?  |
| Do the community use any improvised methods to create drainage or sanitation infrastructure?   |
| Have the community been involved in any municipal/ NGO/ research projects where improved infrastructure was implemented?   |
| Are there concerns/ problems/ issues in the community that you have experienced?   |
| What do you think would be the most important issue for action by favela members?  |

The purpose of the different phrasing of the questions was designed to ensure that interviewees were engaged and felt that their views are listened to and respected. For example, if academic language had been used to elicit responses from non-academics it may have served to alienate interviewees if there was a lack of understanding of the question. Thus, the wording of the questions was tailored to the lived experience of the relevant interviewee groups. Whilst the larger number of “expert” views may lead to an impression that they were regarded as more significant, this was not the case and responses were given equal weight irrespective of their origin. Due to the difficulties encountered with access to the favelas during the field visit as explained in section 2.2, planning of any future work would need to investigate the incorporation of a wider range of community interviewees, if possible.

### 3. Results

The result of the Template Analysis was in the form of a ‘codebook’ containing key codes in 5 broad thematic areas including 15 Categories (indicated by upper case Roman numerals: ‘I.’), 58 sub-categories (lower case letters ‘a.’), 117 primary sub-categories (lower case Roman numerals ‘i.’) and 55 secondary sub-categories (numbers ‘(1)’). An example of one of the outputs of this process is given in Table 3.

Table 3 Example output of the coding process using “sanitation” as the key word

- I. SANITATION IN BRAZIL
  - a) POTABLE WATER
    - i) SUPPLY CHALLENGES
    - ii) CONTAMINATION
  - b) SEWAGE REMOVAL
    - i) COMBINED SEWERS
  - c) SEWAGE TREATMENT
    - i) LACKING SEWAGE TREATMENT WORKS
    - ii) RAW SEWAGE DISCHARGED BY OCEAN OUTFLOW
  - d) DRAINAGE
    - i) GREYWATER
    - ii) STORMWATER
    - iii) FREQUENT FLOODING
      - (1) BLOCKED DRAINS/GULLY POTS/PIPES OVERFLOW
    - iv) LOWEST GOVERNMENT SANITATION PRIORITY
      - (1) UNMAINTAINED INFRASTRUCTURE
- II. SANITATION INFRASTRUCTURE AGENDA
  - a) EVERYONE
    - i) INADEQUATE CAPACITY
    - ii) POOR QUALITY
    - iii) LEGAL AREAS ONLY
  - b) FAVELAS
    - i) UPGRADING/IMPROVING
    - ii) RELOCATION
    - iii) REMOVAL
- III. FORMAL DRAINAGE IN FAVELAS
  - a) CEILANDIA (BRASILIA)
  - b) ROCHINA (PAC PROGRAMME)
    - i) SUPPORTING NATURAL DRAINAGE
    - ii) CHALLENGE OF SEWAGE DISPOSAL
  - c) NOVA IGUAÇU
    - i) CENTRAL NETWORK PROVIDED
    - ii) HOUSEHOLD RESPONSIBLE FOR OWN CONNECTION
- IV. COMMUNITY INITIATED SANITATION
  - a) PRAIA DO SONO
    - i) EVAPOTRANSPIRATION TANK
    - ii) FOR HOUSEHOLD GREY & BLACK WATER
    - iii) CONDENSED VAPOUR COLLECTED, USED FOR AGRICULTURE

### 3.1 Outcomes of interviews

Participants across the board suggested that “government support, capital and resources” were vital if any strategy was to be implemented with additional support from other stakeholders. This would enable them to “work together and exchange ideas” with the favela community in order “to give [them the] knowledge and ability to identify and understand their own problems, so they can work towards solving the issues themselves”. These statements were given in response to both sanitation issues and also reduction of incidences of ZIKV. Responses from participants firstly covered the feasibility of SuDS in general and then the potential of using SuDS to specifically address ZIKV.

### 3.2 The feasibility of using SuDS in favelas

In comparison with traditional approaches to drainage, participants were reasonably positive about the benefits of a simple SuDS design for favelas, such as that suggested by Charlesworth et al., 2022 (e.g. a gravel filled ditch, cleared of solid waste, allowing the water to infiltrate below the surface). They commented that “drainage does not need pipelines to be innovative... nature-based solutions like infiltration ... may be more appropriate after studying how ecosystem and drainage problems interact”. Similarly, more work on “installing

green roofs in favelas” was one of the suggestions. Furthermore, the benefits of SuDS in terms of sustainability and biodiversity were raised by three of the participants who also prioritised solutions that had the potential to improve both environmental and public health. However, one participant stated “there is no straightforward solution, and the policies we currently have are likely not going to help.”

Whilst most of the comments regarding whether SuDS would be feasible came from external stakeholder, members of the favela community were aware of the need to improve drainage options and felt that there were appropriate skills in the community which would enable the construction of straightforward SuDS devices. The challenges identified were lack of a funding mechanism, which it was felt had to come from the government, and provision of specific knowledge: “many [favela] areas have people who are bricklayers ... and build their own septic tanks. ... the challenge is how to spread this knowledge ... many people feel the government should be providing ... and paying to build their drainage systems”.

### 3.3 The potential for improved sanitation to reduce breeding opportunities for the ZIKV-carrying *Aedes aegypti* mosquito

Participants gave similar views on the ability of any form of improved sanitation and drainage infrastructure to address issues around disease vectors, specifically proliferation of ZIKV. Many were of the opinion that “low-scale [sanitation interventions] will not work, sanitation on a large scale is needed because mosquitoes can fly” and thus the insect can “go everywhere”. Others felt that a more holistic approach was preferable since “drainage [and sanitation] on its own will not be able to do this” and “you need education on health, environment ... and the connections between ... drainage and the mosquito”. It was felt that just targeting favelas would not resolve the problem since ZIKV infections had also been confirmed in the formal areas of Rio. Whilst some in both groups were aware of the links between sanitation and health, there were also examples from both groups where this was not the case.

Responses fell into four main categories:

- Suitable project management and engagement with the community (GOVERNANCE NEEDS);
- The public need to be better aware of water-related issues (EDUCATION, AWARENESS BUILDING);
- Addressing water, sanitation and drainage challenges in an integrated and holistic way, including dealing with vector-borne disease and other health issues at the same time (ENVIRONMENTAL HEALTH);
- Investment in new and improved sanitation and solid waste management infrastructure, in the urban environment as a whole rather than small-scale single interventions (LARGE- SCALE APPROACH, GOVERNMENTAL WILLINGNESS, ADAPTABLE TO CLIMATE CHANGE).

The coded diagram of results given in Figure 2 summarises both the views of participants regarding current challenges, and also potential solutions that might be implemented in the future to resolve the problem of ZIKV in favelas. The diagram is based on the analytical codebook and uses the 4 themes: Governance, Favelas, ZIKV and Sanitation, each of which is colour coded. Figure 2 is based on the comments of participants only, and there may be further challenges and solutions that were not covered in the interviews.

The challenges are given to the left of Figure 2; each branch and its connected strand are sorted by theme, the added colours give an indication of potential relationships with the other themes. For example, lack of management of solid waste is specific to favelas, so the text is in purple, and underlined in blue to reflect that this is grounded in inadequate sanitation infrastructure. The sanitation branch,



including both the infrastructure agenda and its subcategories are underlined in red, highlighting the need for the involvement of governance to enable the application of effective sanitation.

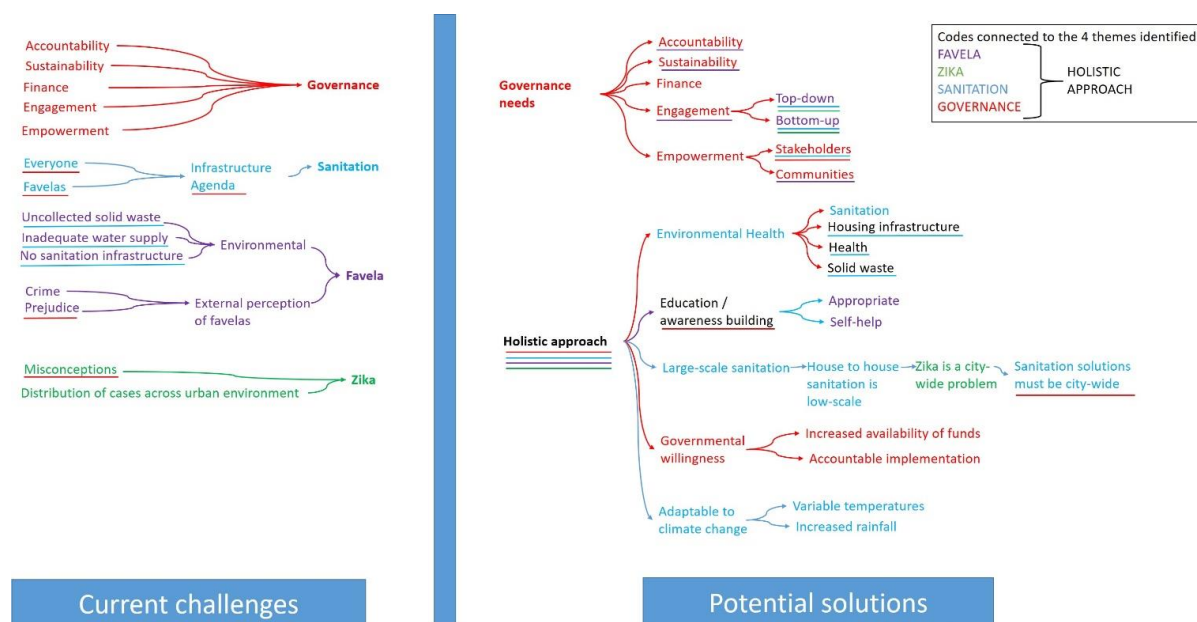


Figure 2 A coded diagram to illustrate the current challenges and potential solutions identified by participants.

The right-hand side of Figure 2 highlights potential solutions, which were raised in response to the interview questions. The same colours have been used for both the challenges and the solutions, which emphasises the complexities and levels of inter-dependency linked with each solution suggested. Participants recommended that the most useful approach had to be both multidisciplinary and holistic in order to address the combined issues around ZIKV and sanitation. Overall, and at all levels of stakeholder involvement, governance needs to be flexible to enable changes to be made to conditions associated with sanitation, as well as regulations and procedures. Unfortunately, and brought out clearly during the interviews by participants themselves, it was acknowledged that the favela community may have to take responsibility and ownership of their own specific situation in order to address the issues raised. This is a direct consequence of the informality of their living conditions, allied therefore to a lack of interest by government to act to improve the situation.

### 3.4 Areas requiring action

Findings were related to the following four main areas:

#### 3.4.1 Project management and engagement of the community

It was generally accepted that there are issues with certain levels of corruption in Brazil (Rose-Ackerman and Mattos Pimenta, 2020) with many of the study participants stating that the most burning issues associated with government projects included “financial accountability” and the lack of “sustainability”. It was suggested that funds were often used inappropriately, and the design of projects did not have “sustainability at the[ir] heart”.

Hierarchical structures in the favela (i.e. drug lords and their associates) meant continual distrust between both internal and external actors exacerbated by inflammatory police raids. These issues have been identified in the context of past slum-upgrading and household infrastructure improvements (Denaldi et al. 2016; Ren 2018; Samora 2016). More recently, high court corruption investigations and major sporting events have disrupted government budgets and agendas.

Participants from both groups believed that there was a need for collaboration and approaches that were “community-led” and “work with [existing] skills and knowledge [of the community]”. One of the external experts also suggested that “you have to have conversations ... and ask them [the community] their opinions and discuss methods of collaboration” so that the community can be encouraged to “improve and sustain themselves” enabling “sufficient jobs ... and develop skills to ensure dignity for the community ... [and for] future community-led improvements”. Relying on the community to make such improvements itself may be distasteful to some in the Global North, who may consider that it is the Government’s responsibility and may reflect outdated attitudes of the era of colonisation. However, in Karachi, Pakistan, the Orangi Pilot Project–Research and Training Institute (OPP–RTI) supported the delivery of sanitation and other services in the Orangi Town informal settlement (Hasan, 2006). This project was able to demonstrate that an informal community is capable of financing, building and managing the development of an internal sewerage system; however, this was based on technical and managerial support from OPP–RTI. It is notable that the project was subsequently able to build positive relationships with local government officials including engineers and administrators who were then willing to provide support.

#### 3.4.2 Increased public awareness of water-related issues

In the absence of public engagement with improvements to sanitation, it was proposed by both groups that educational activities, implemented early in the delivery of projects could increase awareness of “the risks and consequences of a polluted environment”. One expert participant recognised that: “without sanitation education, we cannot try to bring people together” as it is when “behaviour changes” that people “will see the issues” and become involved in solving problems with inadequate sanitation.

#### 3.4.3 Integrated and holistic approaches

The issue is not simply due to inadequate sanitation, there are other issues affecting life in the favelas which were brought up in the interviews including “living conditions, income, [and solid] waste collection”. It would be useful to be able to tackle such issues holistically, due to the connection between public and environmental health. However, participants acknowledged that Brazilian policy-makers “don’t always link everything together” such that the actions of one department may be disrupted by the agenda of others. Therefore, approaches need to be integrated and collaborative to “effectively deal with these issues”. Figure 3 shows how the connections and relationships around provision of adequate sanitation can be holistically managed to address infections of the ZIKV.



Figure 3 An integrated holistic approach to address inadequate sanitation, governance and solid waste management to address the distribution of ZIKV in Brazil

#### 3.4.4 Increasing investment in sanitation and waste infrastructure

Although the opinions of expert participants were mostly positive when considering government investment, two were skeptical due to the level of financial support required and the scale of the projects needed: “I think these problems can be solved ... some solutions have been made ... I’m not saying there’s no solution, but it would take a very large intervention from the government”.

Furthermore, there was particular concern in both groups regarding extreme weather events, with any systems under consideration needing to be designed to account for the current climate and also predicted climate change, since “we are struggling to deal ... with existing systems in the current climate ... those with no systems are just going to get worse”. Regarding the scale of interventions “sanitation must be everywhere, by only improving one neighbourhood you’re not improving everywhere” which supports earlier concerns which were raised around the ability of the *Aedes aegypti* mosquito’s ability to fly anywhere, as well as the close relationship between drainage and hydrology across the city as a whole.

#### 4. Discussion

All participants recognised prejudice and lack of willingness of the government as the most significant barriers to addressing issues around the lack of sanitation infrastructure in favelas, this in spite of there having been interventions implemented before. Six of the 16 participants also identified high levels of “drug trafficking and insecurity....corruption and crime hierarchy within the favelas” that were major factors hindering the government and communities working together resulting in the favela community being prevented from accessing publicly funded support and services. Several participants who were external stakeholders also stated that many families living in the favelas “do not want to live without services or in violent areas, they simply have no choice”, and that it is the “drug traffickers who [hold] power ... and often do not permit [government and livelihood] activities”. In addition, the ongoing disputes over land legality and the focus of utility companies on their profits meant investment in sanitation mainly occurred in “wealthier areas [where companies] can make good profits”.

Despite recent government agendas working against upgrading initiatives in favelas, participants mentioned the positive impacts of previous initiatives. One in particular which was mentioned was “the Profa e programme ... [which brought] infrastructure to the favelas in the form of drinking water and sewage”, which was based in the Rocinha favela (southwest Rio de Janeiro). One participant was positive about the ongoing Community Health Worker initiatives, which train favela residents, in that they felt “they are the closest government solution that

educates on the links between health and the environment”. However, in spite of the government endorsing favela relocation projects, suggesting that they were successful in terms of initiatives leading to upgrading and integration, one participant disagreed, stating that “the government see improved apartments [social housing provided by favela-removal projects] as a formal area. ... [But] social initiatives are only to help families ... living in informal areas [so we miss out]”. Therefore, favela residents may be provided with better housing and infrastructure, but they are still in low-income occupations and continue to be prevented from accessing any wider social initiatives. Thus, whilst claims that such initiatives reverse poverty, in fact they contribute to chronic low socioeconomic status, since families that have been relocated to better conditions “aspire to work, [but] they still return to [livelihood] conditions of poor development”.

Water supply challenges during the summer months were also an issue with consequences in both formal and informal settlements, particularly in 2015 before the Olympics since “there were many problems with scarcity of water. The government had to turn off the water to many homes and apartments [in Rio de Janeiro]”. This led to households storing water inside with increased potential for contamination, particularly with disease vectors, and poor water quality. In the past, some infrastructure projects tried “to connect [favela] communities to water ... but the supply was never consistent... often slums are the last point on the water network. ... This sometimes reduces the water pressure and so the water does not reach the communities”. Some of Rio de Janeiro’s favelas are situated upslope of the formal areas (Charlesworth et al., 2022), requiring water to be pumped uphill, adding to related expense and infrastructure. Flooding and landslides were also raised as major issues, with stormwater flooding related to insufficient drainage systems “causing a build-up of water and sewage ... so when there is a lot of rain it floods”. Fluvial flooding was also mentioned, affecting “favela communities located on flat areas [river-banks and flood plains]”, “as they are below the maximum level of the river”. Landslides were also a “severe issue [in hilly areas], caused by greywater and stormwater” since the soil is thin which becomes saturated and unstable following heavy rain.

In order to address the lack of drainage and greywater management infrastructure, there are occasions whereby communities “buy the materials ... and do it themselves”. Unfortunately, this can lead to negative impacts on human and environmental health due to the “discharge of sewage into the rivers” with “illegal connections into [formal] drainage systems” which “contaminates the potable water supply”. However, a participant from Bahia State said that “greywater disposal [relies] on the slope of the favela, but sewage was kept in a septic tank under the toilet”. This shows that it is possible for appropriate infrastructure to be installed in favelas, but in this case it was built and maintained by the community. In another positive instance, a participant in Nova Iguaçu (a municipality north of Rio de Janeiro), stated that “the government builds [a] central [sewer] system and then each family is responsible for their connection ... [as a result only] 30-40% of the people in Nova Iguaçu are on the poverty line”.

This small number of examples of improved sanitation implemented in favelas goes some way to explaining why 9 of the 16 participants showed a lack of understanding of the link between sanitation and human health; and in spite of advice given by community health workers, “communities [continue to] perceive the river ... as a sewage channel”. Whilst this attitude is disappointing, one participant gave the example of a resident’s association in an area of relocated housing which “ensures people dispose of their waste properly” and also made attempts to construct flood barriers around the dwellings. Similarly, “many [favela] areas have people who are bricklayers ... and build their own septic tanks. ... the challenge is how to spread this knowledge, ... many people feel the government should be providing ... and paying to build their drainage systems”. For many households in favelas, problems with sanitation are not perceived as an issue “because it is outside of their reality” since “how they will eat and how their children survive ... is a bigger worry for them”. When considering improvements to quality of life for those living in favelas, it is necessary to engage with them in order to prioritise what is best for community health and wellbeing and for the environment.

## Conclusion

This study has shown that, whilst the favela community in Rio de Janeiro, and those that work with them, acknowledge the importance of drainage and greywater management, nonetheless there are other challenges they feel are of more, or equal, importance; the main challenge being simply surviving from day to day. Most participants recommended taking a holistic approach which would consider not only issues around drainage, but also the sustainable management of both solid and human waste. Results highlighted lack of knowledge as an issue, not only for the favela community, but also for some of the stakeholders whereby the connection between the mosquito and sanitation had not been made. Whilst government support to improve conditions was mentioned, the fact that favelas are “informal” means that the community has to rely on the expertise of its members to address such issues. This conclusion was expressed by the community themselves and was an acknowledgement of their need of the knowledge to become self-reliant. Where possible, therefore, it is recommended that support is provided in terms of information and education to assist the community to become independent, delivering the knowledge necessary to address problems the government is currently reluctant to engage in. In the longer term, however, there is a need for greater local and national government awareness and involvement in providing basic infrastructure, facilities and drinking water supplies. More widely, and as stated by the WHO (2022), by improving water supplies and providing suitable sanitation, a country's economic growth is increased, and poverty is reduced, leading to clear benefits in terms of addressing public and environmental health costs and concerns; there is therefore a need for a more coordinated focus by governments on these issues.

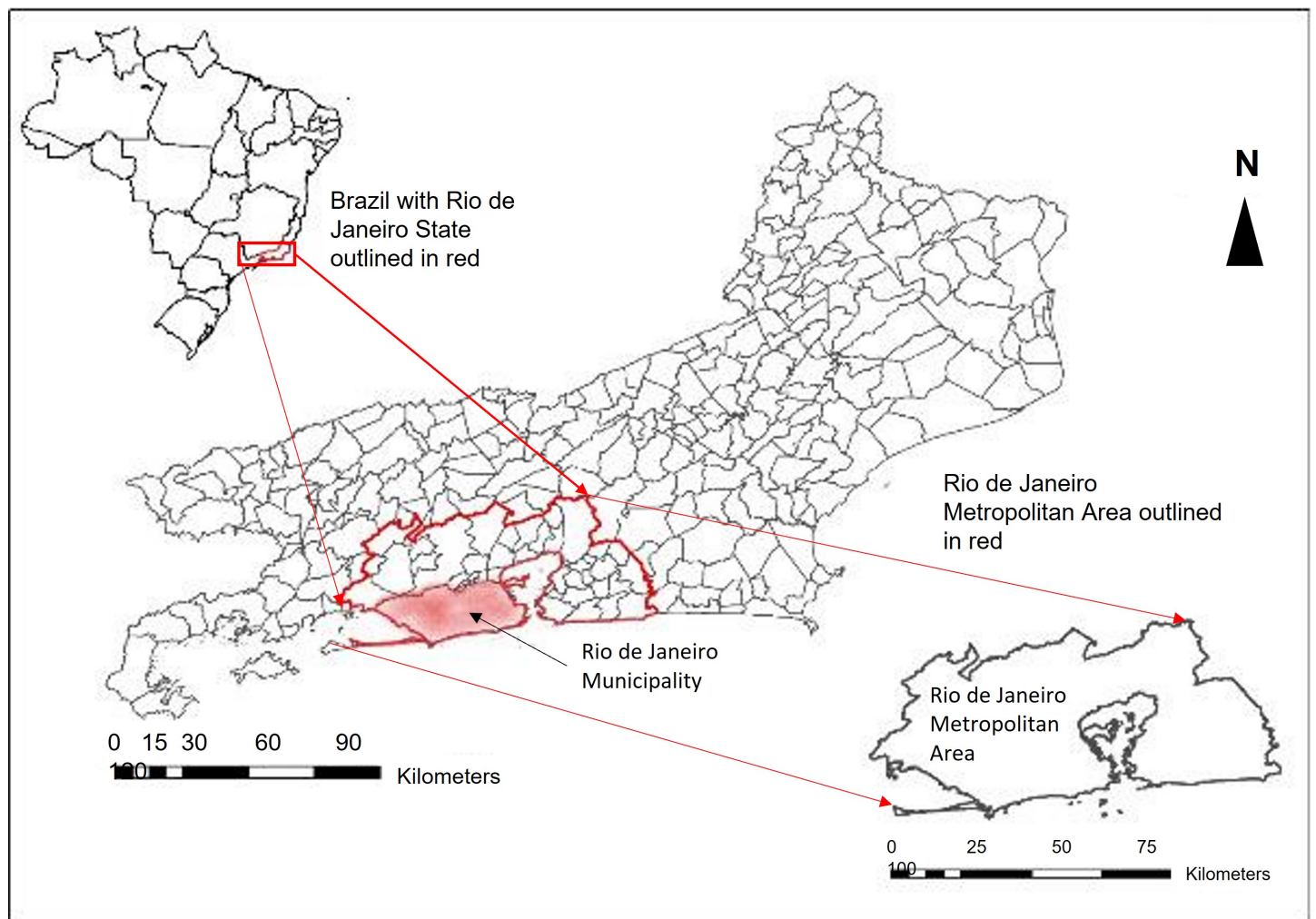
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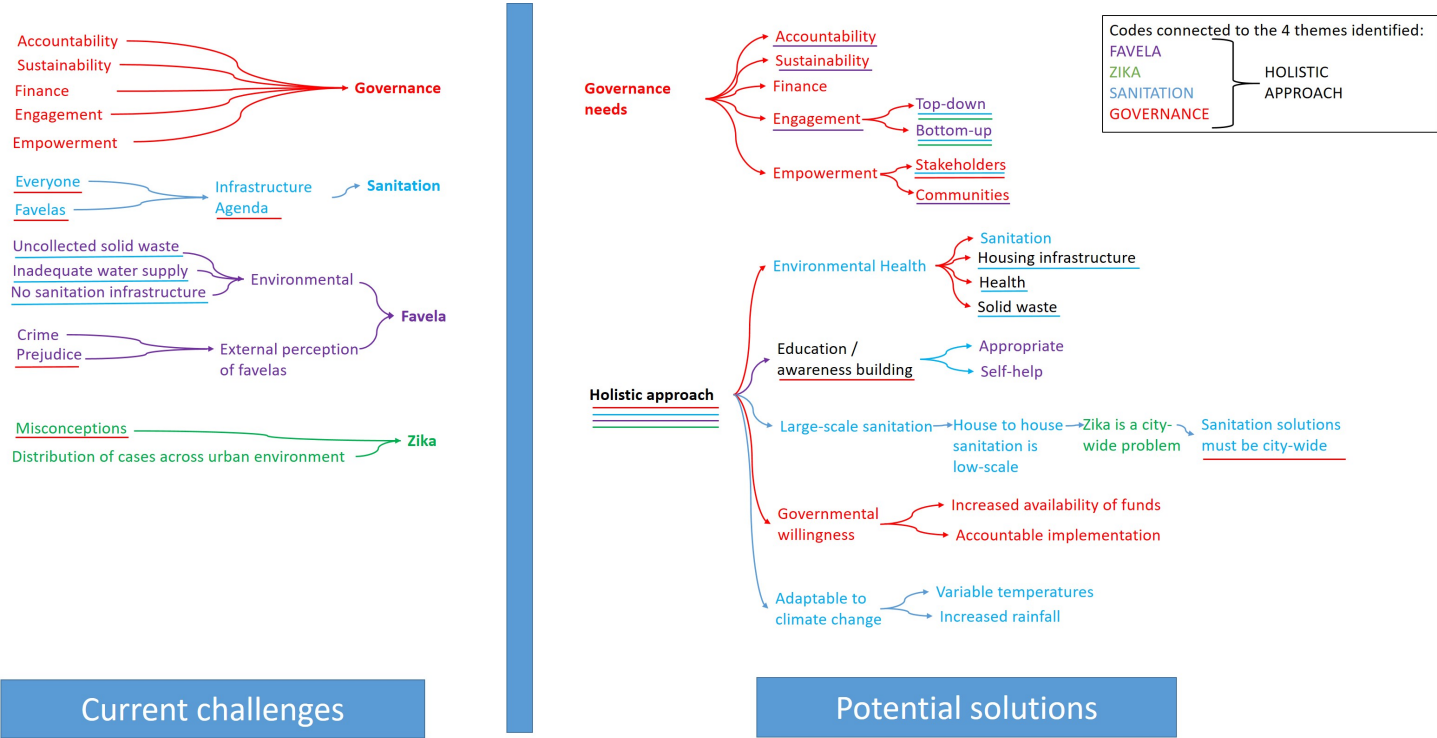
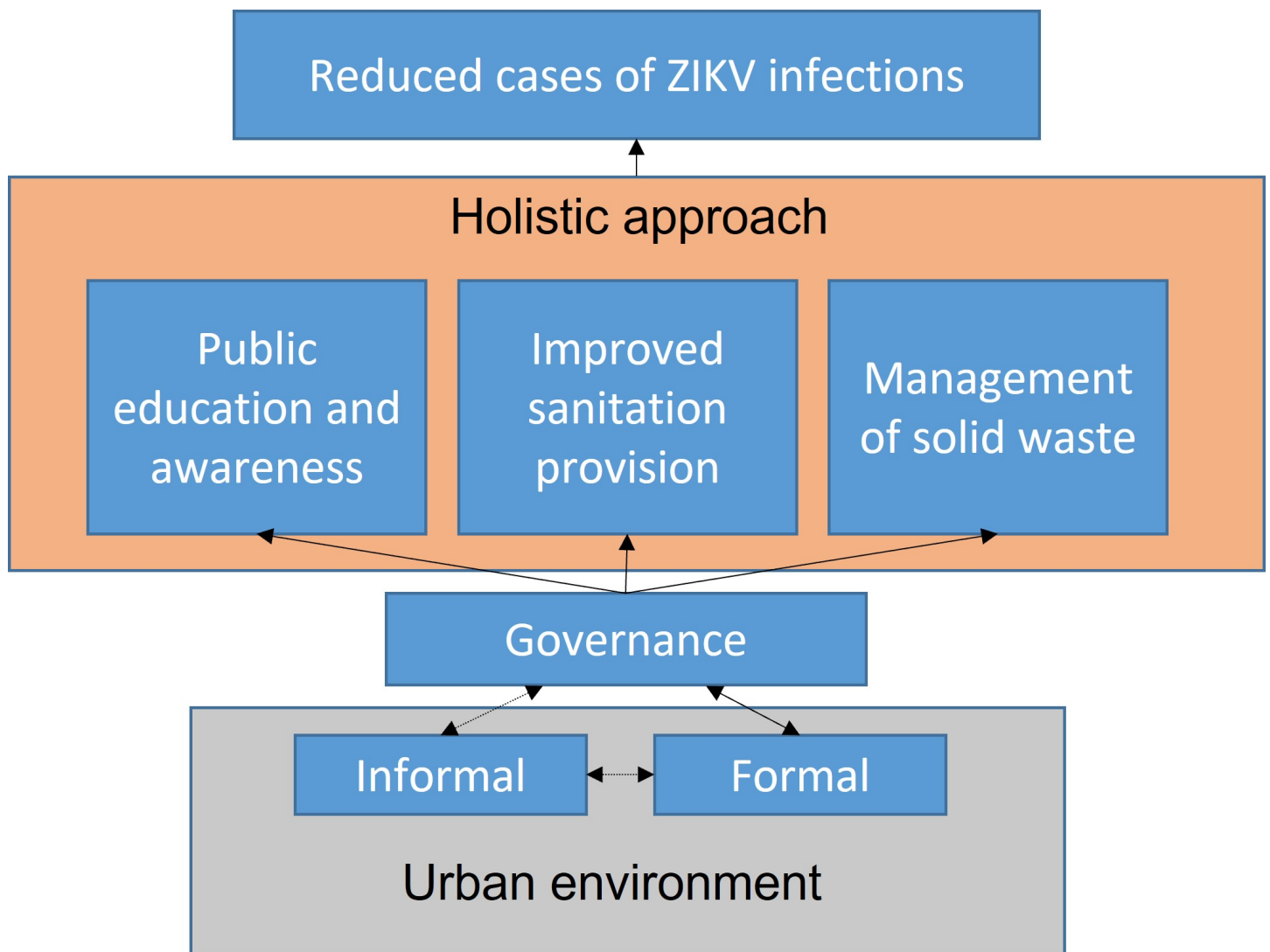


Fig 2.jpg Figure





## I. SANITATION IN BRAZIL

### a) POTABLE WATER

- i) SUPPLY CHALLENGES
- ii) CONTAMINATION

### b) SEWAGE REMOVAL

- i) COMBINED SEWERS

### c) SEWAGE TREATMENT

- i) LACKING SEWAGE TREATMENT WORKS
- ii) RAW SEWAGE DISCHARGED BY OCEAN OUTFLOW

### d) DRAINAGE

- i) GREYWATER
- ii) STORMWATER
- iii) FREQUENT FLOODING
  - (1) BLOCKED DRAINS/GULLY POTS/PIPES OVERFLOW
- iv) LOWEST GOVERNMENT SANITATION PRIORITY
  - (1) UNMAINTAINED INFRASTRUCTURE

## II. SANITATION INFRASTRUCTURE AGENDA

### a) EVERYONE

- i) INADEQUATE CAPACITY
- ii) POOR QUALITY
- iii) LEGAL AREAS ONLY

### b) FAVELAS

- i) UPGRADING/IMPROVING
- ii) RELOCATION
- iii) REMOVAL

## III. FORMAL DRAINAGE IN FAVELAS

### a) CEILANDIA (BRASILIA)

### b) ROCHINA (PAC PROGRAMME)

- i) SUPPORTING NATURAL DRAINAGE
- ii) CHALLENGE OF SEWAGE DISPOSAL

### c) NOVA IGUACU

- i) CENTRAL NETWORK PROVIDED
- ii) HOUSEHOLD RESPONSIBLE FOR OWN CONNECTION

## IV. COMMUNITY INITIATED SANITATION

### a) PRAIA DO SONO

- i) EVAPOTRANSPIRATION TANK
- ii) FOR HOUSEHOLD GREY & BLACK WATER
- iii) CONDENSED VAPOUR COLLECTED, USED FOR AGRICULTURE