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Investigation of a *Salmonella* Typhi cluster among a Pacific Islander labour community in a fruit industry: perspective from a regional public health unit

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Abstract

Background

Australia is largely dependent on immigrant workers to bridge the employment gap in the agricultural sector and in agriculture-related food production; this poses a potential risk of the introduction and transmission of non-endemic vaccine preventable disease. We report the response to a *Salmonella* Typhi (*S*. Typhi) outbreak amongst workers from the Pacific Australia Labour Mobility (PALM) scheme in regional Queensland.

Methods

A cluster of invasive *Salmonella* infections was investigated in accordance with the Communicable Diseases Network Australia guidelines. Active case finding of the at-risk group was undertaken to identify potential causal links and further transmission.

Results

Three confirmed cases of *S*. Typhi were reported, all male, with a median age of 31 years (range: 29–33 years). All cases were hospitalised and were managed with antibiotics and supportive care, with a median illness duration of nine days. Full recovery was reported for all cases, without complications. No recent travel history or contact with a recent typhoid case were reported. We identified 310 individuals in the exposed cohort, with a median age of 31 years (range: 22–55 years), all males. Of the exposed cohort, 305/310 individuals (98·4%) provided a faecal sample for *S*. Typhi testing; all returned a negative result. Genomic sequencing concluded the likely source of infection in this outbreak was chronic carriage of *S*. Typhi.

Conclusions

Australia has had a significant increase in the number of PALM workers in regional areas, particularly within the agricultural sector, to mitigate employment gaps. A greater emphasis on culturally appropriate and linguistically sound hand hygiene education, and consideration of pre-employment health checks and vaccinations in these workers, would be beneficial in the reduction of communicable disease outbreaks.

Keywords: Pacific Australia Labour Mobility (PALM) scheme; *Salmonella*; *Salmonella* Typhi; regional Queensland; outbreak; diseases

Introduction

The Pacific Australia Labour Mobility (PALM) scheme is a major temporary migration program implemented to address labour shortages across rural and regional Australia, in the agricultural and selected food-related production industry nationally.[1] Under the scheme, Australian businesses recruited more than 35,000 PALM workers (from Fiji, Vanuatu, Kiribati, Nauru, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, and Tuvalu) for short- and long-term placements (6 months to 4 years) as of December 2022.[2] A substantial increase of 44% occurred between May and December 2022 in the number of PALM workers employed in regional areas, particularly in agricultural sectors.[2] In 2023, a report from the Department of Agriculture, Fisheries and Forestry (DAFF) noted the likely underestimation of temporary and seasonal agricultural workers due to point-in-time data collections (e.g. census data) and language and literacy barriers, with this report stating that 33% of the employees in Australia's fruit and nut growing industry were from culturally and linguistically diverse (CALD) backgrounds.[3] While the PALM scheme has been described as a 'win-win' for Australia and the Pacific,[4] or as a 'triple win' for the individuals participating, the Pacific Island economies, and the Australian economy,[5,6] there have been concerns raised about workers' safety and wellbeing.[7] There have been recent anecdotal reports of enteric disease clusters or outbreaks among PALM workers working in regional Queensland.[i]

The global movement and migration of populations play a critical role in the spread of infectious diseases, initiating outbreaks of acute diseases, altering the prevalence of existing infectious disease within communities, and changing the trend of chronic diseases.[8] Currently, there are no pre-departure vaccine requirements among working migrants from countries participating in the PALM scheme and the prevalence of vaccine-preventable diseases (VPDs) (e.g. typhoid, hepatitis A, hepatitis B, tuberculosis) amongst this population is also largely unknown.[9] Whilst Australia has funded vaccinations available for many VPDs (e.g. hepatitis B), there is still a risk of disease transmission among the host population when there is low existing immunity and vaccination rates for some VPDs non-endemic to Australia (e.g. typhoid).

The burden of foodborne illness in Australia is high, with an estimated 4.1 million infections from contaminated food, costing approximately AUD 2·4 billion each year.[10,11] Major episodes that increase cost are attributed to non-fatal illness, followed by premature mortality, hospitalisation and associated health care expenses and lost productivity. For the year 2019 in Australia, Food Standards Australia New Zealand (FSANZ) has estimated the occurrence of 61,600 cases of non-typhoidal *Salmonella* (90% uncertainty interval [UI]: 34,300–109,000) and 29 hospitalised *Salmonella enterica* subsp. *enterica* serovar Typhi (*S*. Typhi) cases (90% UI: 10–64) circa 2019 in Australia.[10] The largest financial burden from foodborne disease within Australia arises from pathogens that typically cause more severe illness such as *Listeria monocytogenes*, Shiga toxin-producing *Escherichia Coli*, and *Salmonella*.

The Central Queensland Public Health Unit (CQPHU) responded to a typhoid outbreak (*Salmonella Typhi*) in regional Queensland among three PALM scheme workers. *S*. Typhi was identified as the pathogen; molecular typing was used to confirm a link between the cases and to establish possible sources of infection. This report highlights the need to maintain disease surveillance among PALM workers and to incorporate recommendations on public health policy in order to reduce the potential risk of outbreak propagation and health hazard to the wider population and impact on the industry.

Methods

On 27 August 2023, two individuals with evidence of bacteraemia were reported to the CQPHU following their presentation to the local emergency department. On 31 August 2023, a third case diagnosed with invasive salmonellosis was admitted to hospital and geographically linked to the two reported cases.

Data source

Notification of the *Salmonella* cluster was based on laboratory confirmed evidence of positive *Salmonella* bacterial culture from blood specimens, in conjunction with an epidemiological link. Initial suspicions of possible enteric fever infection were later confirmed by blood culture isolating *Salmonella* Typhi. Infection by *S*. Typhi is a notifiable condition in Queensland, with confirmed cases reported to the Notifiable Conditions System (NoCS).[12]

i personal communication, Gulam Khandaker.

Study design and setting

A case-series analysis was conducted from 20 August 2023 (case 1 symptom onset date) to 5 October 2023, providing enhanced surveillance for effective public health response in accordance with the Communicable Diseases Network of Australia (CDNA) guidelines.[12] The notified cases were part of the PALM scheme working in a regional fruit industry. The cases had all arrived in Australia in January 2023, with no other reported recent travel history. A total of 310 workers (fruit pickers and cleaners) were identified as the at-risk population in this *Salmonella* cluster. All were living in two large accommodation camps and multiple smaller shared dwellings, all with shared self-catered cooking facilities and communal areas.

Outbreak and case definition

In accordance with the CDNA case definition and Queensland Health guidelines for Public Health Units (PHUs), a *Salmonella* cluster can be defined as a geographically linked cluster of cases infected with the same *Salmonella* serotype, genotype or phage type.[13,14]

A confirmed case of *S*. Typhi requires laboratory definitive evidence of isolation or detection of *S*. Typhi from any clinical specimen.[12]

Identification of two or more geographically, temporally or epidemiologically linked cases of *S*. Typhi infection meet the community outbreak criteria, prompting a Public Health response and investigation to determine the likely source.[12]

Public health and infection prevention and control measures

CQPHU declared the *Salmonella* cluster a community outbreak on 28th August 2023, adopting an outbreak definition consistent with CDNA and Queensland Health guidelines.[13,14]

Following the outbreak's declaration, CQPHU launched an immediate response team to conduct a site visit and investigate the cluster. The team consisted of two Environmental Health Officers (EHOs), a Public Health Registrar and a Public Health Nurse (PHN). The focus of the site visit was to determine the risk (if any) to the wider community; to establish any potential modes of transmission; and to provide immediate mitigation advice to reduce the risk of further transmission. On the same day, an incident management team (IMT) was established between the CQPHU and the food industry management team.

Regular communication between the CQPHU team and the affected site's relevant stakeholders was established to quickly identify any new or potential cases.

The site inspection allowed assessment of the existing living arrangements, including sleeping, bathroom, and kitchen facilities where workers prepared their own meals; washing, water supply, shared communal areas and hand washing facilities were also assessed. Work areas were also reviewed, to assess communal areas such as toilets, access to hand hygiene, and availability and storage options for food and water while working in the field.

As this *S*. Typhi cluster occurred amongst food handlers, the EHOs assessed the process of food manufacturing prior to distribution, to assess for risk to food consumers within the broader population.

CQPHU implemented a multifaceted response to control the outbreak and to reduce transmission risk among the resident employees in the affected site as per Public Health guidelines.[14] Confirmed cases received antibiotic treatment and were excluded from work and contact with other workers until deemed no longer infectious. Cases were determined no longer infectious 48 hours after resolution of symptoms and with two consecutive polymerase chain reaction (PCR) and culture negative (for *S*. Typhi) stool specimens taken a minimum of 48 hours apart, with the first collection occurring ≥ 48 hours post cessation of antibiotics. Culturally and linguistically appropriate face-to-face education and information leaflets were provided to all workers to alert them to the outbreak and to encourage reporting of symptoms to identify and isolate potential cases. Appropriate signage was placed throughout the facility highlighting infection prevention and control measures, behaviour and practices focussing on safe water, sanitation, and hygiene (WASH) interventions. Hygiene education was also provided to all confirmed cases and to the potentially exposed population within the affected cohort. Enhanced infection prevention and control and hygiene measures were recommended by the CQPHU and implemented by the facility. These included immediate isolation and clinical review of newly symptomatic workers, increased hand hygiene stations, increased cleaning frequency of communal kitchen, recreational and ablution facilities, assignment of dedicated staff to clean toilet facilities, placement of culturally and linguistically appropriate signage and the isolation of confirmed cases post discharge until clearance

was achieved. The local hospital Emergency Department and general practitioners (GPs) in the area were notified via written communication, alerting them to the outbreak and requesting a low threshold for testing patients presenting with symptoms consistent with *S*. Typhi infection. A typhoid vaccination campaign for the PALM resident workers was immediately organised to interrupt the transmission chain, improving immunity within the at-risk population.

Laboratory investigation

Whole genome sequencing was requested to investigate possible links with other clusters. The sequences were generated using the Illumina NextSeq genome sequencing platform in the Public Health Microbiology laboratory, Public and Environmental Health, Forensic and Scientific Services. Sequences were trimmed using Trimmomatic v0·36 and were de novo assembled using the SPAdes assembler V3·12·0.[ii] Core genome multilocus sequence typing (cgMLST) was performed in Ridom SeqSphere+ v9·0·8 using the scheme from Enterobase.[iii] The cgMLST technique is a molecular typing method that uses differences in core genes to generate high-resolution species typing results and to analyse the population structure and genetic evolution of strains; this technique can identify the genomic similarities or differences between pathogens and quickly trace the source of the pathogen.[15]

Ethical considerations

Ethical exemption with approval to publish was obtained from the Central Queensland Hospital and Health Service Human Research Ethics Committee (EX2024QCQ105816). This outbreak investigation was considered an urgent public health matter with all activities performed as a part of the standard response under the Queensland *Public Health Act 2005*.[16]

Results

During the period 20 August – 5 October 2023, a total of three cases of *S*. Typhi were notified to the CQPHU. All cases were male with a median age of 31 years (29–33 years) and treated in hospital with antibiotics and supportive care accordingly. All three cases experienced symptoms of nausea and headache, with two reporting fever, malaise, cough, and joint pain. Rash and blurred vision were also identified as symptoms in one of the cases. The median duration of illness amongst the cases was nine days. No risk factors were reported by any of the cases, including recent overseas travel or contact with a recent confirmed typhoid case. Sleeping quarters were not shared amongst the three cases; however, all attended social gatherings (on multiple occasions), shared meal preparation, dining, and bathroom facilities. All three cases recovered and were discharged from hospital, without any complications. The investigation timeline carried out by the CQPHU is outlined in Figure 1.

Laboratory investigation

Genomic sequencing was requested to investigate a possible link between this cluster and another in a neighbouring region. All three cases in this investigation were confirmed *Salmonella* Typhi-Vi sequences as detailed in Table 1.

ii https://github.com/ablab/spades.

iii https://enterobase.warwick.ac.uk/.

Figure 1: *Salmonella* Typhi cluster investigation timeline by Central Queensland Public Health Unit (CQPHU)

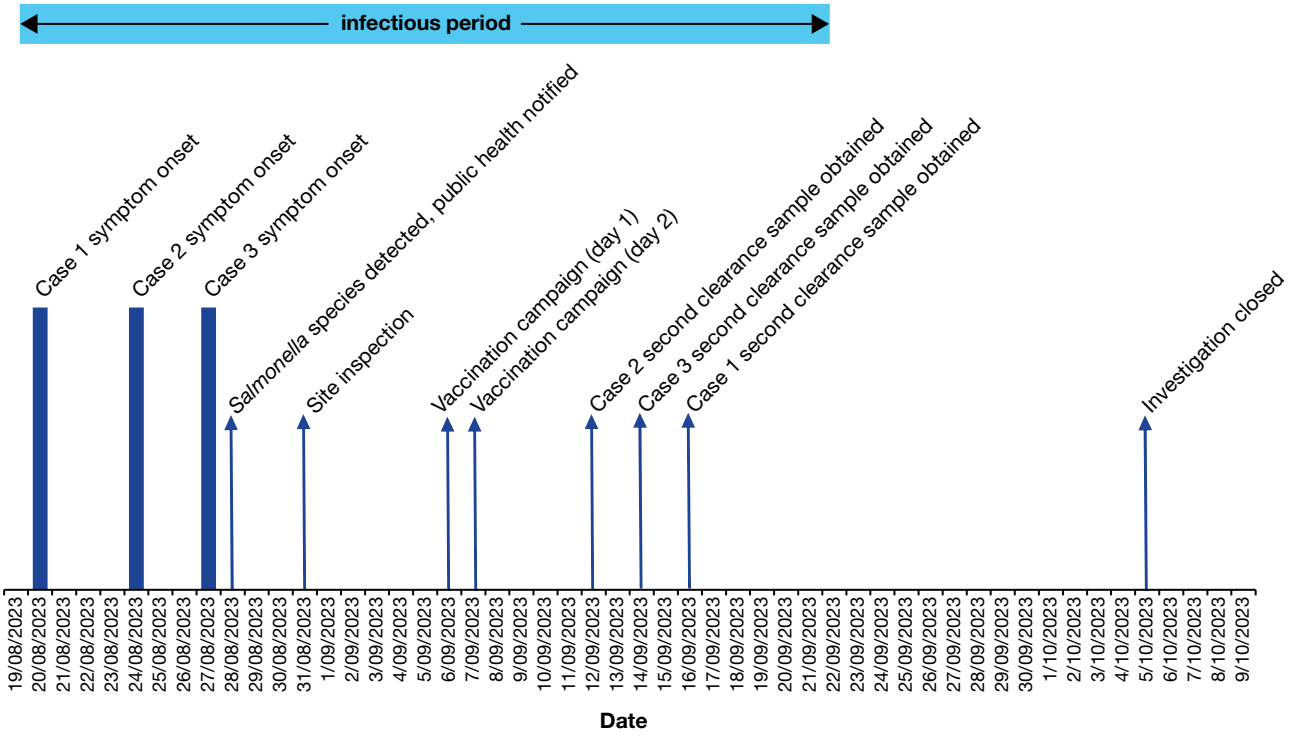

Table 1: Whole genome sequence (WGS) characteristics of the isolates from the cluster

Case	Organism	Serotype	MLST[a]	cgMLST[b]
1	*Salmonella* Typhi	9,12[Vi]:d:-	1	19713
2	*Salmonella* Typhi	9,12[Vi]:d:-	1	19713
3	*Salmonella* Typhi	9,12[Vi]:d:-	1	19713

a Multilocus sequence typing.

b Core genome MLST.

The Neighbour Joining tree (Figure 2) was built using differences in 2,719 cgMLST alleles. The isolates from this investigation are highlighted with blue labels and the cluster is highlighted in purple. The length of branches represents distance between groups as indicated by the scale bar. These isolates showed a high level of genetic similarity to each other, with 0-1 cgMLST allele differences between them. This was higher than the level of similarity seen to other isolates included in the analysis, which had greater than 78 cgMLST allele differences to the cluster isolates. While all three cases in this cluster are linked through shared activities (food preparation and consumption) and social connections/gatherings, cgMLST analysis showed that they were not linked to a neighbouring cluster of *S*. Typhi.

Vaccination intervention and screening

A majority of the employees (98·4%) were vaccinated with a single dose Typhim Vi (Monovalent parenteral Vi polysaccharide typhoid vaccine) as part of the outbreak response.

A total of 305 faecal specimens were provided to Queensland Health Pathology from all resident employees for testing by reverse transcription polymerase chain reaction (RT-PCR), to investigate possible source or carriage status. Three samples returned PCR positive results for *Shigella* (culture negative) and one for *Clostridium difficile* from the asymptomatic workers (Table 2).

Figure 2: Phylogenetic analysis of *S*. Typhi isolates received by the Queensland Public Health Microbiology Laboratory

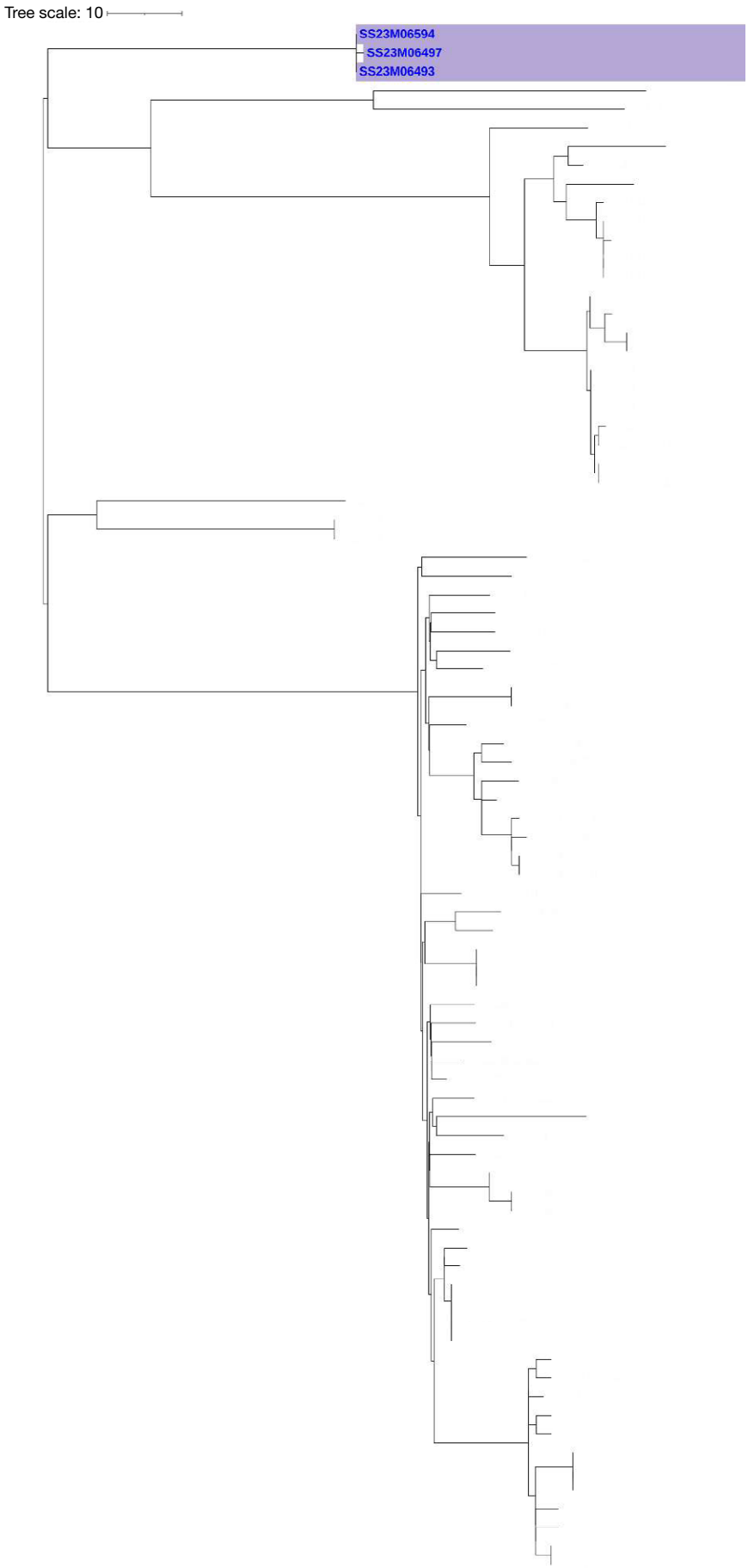

Table 2: Vaccination intervention characteristics and faecal sample surveillance result within the affected cohort

Parameter	Characteristic	Number (N = 310)	Percentage
Age in years	(median, range)	31 (21–55)	—
Sex	Male	310	100
	Female	0	0
Vaccination outcome	Vaccinated with 1 dose of Typhoid vaccine	305	98·4
	Refused	2	0·6
	Deferred[a]	3	1·0
Faecal samples for *S*. Typhi	Positive	0	0
	Negative	305	98.4
	No sample provided	5	1.6
Faecal samples for other organisms	*Shigella*	3	1.0
	C. difficile toxin	1	0.3

a Pre-existing medical conditions resulted in clinicians deferring vaccinations.

Genomic sequencing did not demonstrate a link between this cluster and another *S*. Typhi cluster in a nearby region.

Environmental investigations

All samples obtained from farming equipment and processed food products returned a negative test result by culture, for analysis of foodborne illness pathogens / microbial spoilage.

Discussion

This outbreak suggests a theoretical public health concern regarding imported enteric diseases due to insufficient screening and pre-departure vaccination of PALM workers, especially in the food and agriculture sectors. Ultimately the likely source of infection in this outbreak is chronic carriage of *Salmonella* Typhi. Australia is a low-risk country not endemic for typhoid fever, with fewer than 150 cases reported per annum.[17] While there are vaccines available, they are currently only recommended for those travelling to typhoid-endemic regions.[18] Most typhoid cases in Australia arise from people entering from endemic countries.[17] Establishing pre-departure assessment of at-risk migrant workers may help reduce the risk of typhoid entering Australia. This should include assessment of current exposure risk, infective status and vaccination status. There are no pre-departure typhoid vaccination requirements for migrant workers in countries participating in the PALM scheme. Integrating typhoid vaccine requirement into migration requirements for at-risk migrant workers would reduce transmission risk amongst these groups and the largely unvaccinated, and therefore, unprotected host population.

The living conditions of PALM workers in congregate settings makes it difficult to maintain adequate hygiene to stop the spread of enteric diseases such as typhoid. Current CDNA public health guidelines are targeted for populations with an assumption that WASH is easily maintained and should include recommendations for higher-risk populations and settings. Food handling by a case and sharing of toilets and washing facilities are activities which increase the risk of typhoid transmission.[12] The 310 PALM scheme workers resided in two large, shared accommodation camps and other multiple smaller dwellings. Shared facilities with cases increased the risk of transmission to this group.

To minimise the risk of transmission to those sharing sleeping quarters, bathroom and kitchen facilities, dedicated isolation areas should be made available to at-risk workers. Additionally, vaccination of contacts as prevention measures should be recommended.[19] Vaccination also should be recommended for close contacts (e.g., household contact) of a documented *Salmonella* serotype Typhi chronic carrier (defined as excretion of *Salmonella* serotype Typhi in urine or stool for > 1 year).[20]

Early education of appropriate WASH practices and surveillance methods during a cluster may also assist in reducing the risk of exposure and transmission in vulnerable PALM scheme workers. Integrating culturally and linguistically appropriate education, upon employment, about typhoid fever, recommended pre-departure vaccination, and the importance of hand hygiene may reduce transmission risk. Surveillance methods, including intermittent laboratory surveillance of processed food and farming equipment samples, will contribute to early recognition of contamination.

Timely access to appropriate public health and clinical management is important in suspected cases. If treatment is delayed, 10% of typhoid fever patients may develop severe complications including but not limited to: intestinal perforation, hepatitis, encephalomyelitis, hepatobiliary carcinoma and Guillain-Barré syndrome.[21] None of the cases in this cluster had complications and transmission was contained. There has been enlargement in the size of the PALM scheme workforce in regional Australia in recent years, such as a 44% increase between May and December 2022 in the number of then-current PALM scheme workers,[2] while less than 20% of the medical workforce is found in rural and regional areas, without significant growth.[22] Access to medical care, particularly culturally accessible health care, is an ongoing issue with the PALM workforce in regional and remote Australia where the medical workforce is already stretched.[7]

Typhoid fever can be acquired via faecal-oral transmission and contaminated fomites, and up to 4% of cases progress to chronic carrier status.[23] Infection can be treated with antibiotics such as oral azithromycin, as well as by implementation of hand hygiene, isolation, contact management and education to prevent further transmission.[23] Locally acquired cases in non-endemic countries are due to secondary transmission in close contacts of imported acute disease and to food contamination from chronic carriers; therefore, source control is required.[24] Intimate contacts of chronic carriers require screening and vaccination. Furthermore, 90% of chronic carriers also are found to have cholelithiasis and abdominal investigation should be considered. In future, assessment of carrier status at pre-departure stage via urine or stool is important, as investigation and management implications change.[25]

Regional areas face issues around access to healthcare and the limitation of available housing options.[7] Outbreaks in high-risk settings, such as those with communal living and shared amenities, are challenging to manage. The importance of thorough and frequent cleaning of communal areas (such as food preparation areas, recreation, and ablution facilities) and health messaging of good hygiene practice is paramount to mitigate the spread of disease. PALM workers rely on private health insurance to access healthcare in Australia, which can cause confusion regarding the health services available to them.[7] The provision of culturally and linguistically sound health information and prompt CQPHU response assisted with the successful management of this outbreak.[26] The CQPHU engaged with specific cultural representatives in a bid to mitigate challenges and to ensure health messaging was appropriately communicated. The combination of effective communication and the implementation of infection prevention and control measures largely contributed to the favourable outcome of this outbreak.

Implications for research and public health policy

The agricultural and agriculture-related food product manufacturing sectors in Australia are largely dependent on sourcing employment from immigrant workers (such as the PALM scheme), posing a potential public health risk to the host community. Our experience with the typhoid outbreak highlighted the need for establishing a framework and prevention strategies to ensure the safety and wellbeing of at-risk populations. Currently among working migrants, there is no specific pre-departure or baseline vaccine requirements for VPDs and the prevalence is largely unknown. Prospective surveillance of VPDs (e.g. typhoid, hepatitis A, hepatitis B, tuberculosis, STIs) amongst PALM scheme workers would provide data to promote evidence-based health interventions and to prioritise service provision to reduce the disease burden among scheme workers, as well as to ensure the safety of the host population. Food industries and agricultural manufacturers are also encouraged to promote appropriate health behaviours and WASH practices among employees. This would ensure safe food practices and reduce the potential transmission of emerging and re-emerging diseases from host countries.

Conclusions

Despite the challenges experienced managing the typhoid outbreak among the PALM workers, prompt notification of the outbreak, multi-sectoral coordination, simultaneous streamlined communication across stakeholders with dynamic leadership from the public health response team successfully halted the disease propagation. Future work should focus on establishing a relevant public health policy and research framework for holistic health care provision among the native and migrant population.

Declarations

Ethics approval and consent to participate

Ethical exemption with approval to publish was obtained from the Central Queensland Hospital and Health Service Human Research Ethics Committee (EX2024QCQ105816). This outbreak investigation was considered an urgent public health matter with all activities performed as a part of the standard response under the Queensland *Public Health Act 2005*.

Data availability statement

The research data can be accessed by contacting the corresponding author.

Declaration of interests

The authors declare that they have no competing interests.

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Authors' contributions

GK, JW and CS designed the study. GK, JW, CS conducted the investigation, data curation and project administration. CS, MRH, KD, OW, RG performed the analysis, visualization, and interpretation of the data. GK, JW, CS, MRH, KD wrote the first draft of the manuscript. CS, MRH, KD, GK, JW, OW, RG revised the successive drafts of the paper, which all authors critically revised. CS and MRH then wrote the final version, which all authors approved for publication.

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