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School-based Streptococcal A Sore-throat Treatment Programs and Acute Rheumatic Fever Amongst Indigenous Māori: A Retrospective Cohort Study

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Background: Acute rheumatic fever (ARF) predominantly affects indigenous Māori schoolchildren in Bay of Plenty region, and more so male Māori students, especially when socioeconomically deprived. We evaluated the effectiveness of strategies for reducing ARF with group A streptococcal pharyngitis treatment in 2011–18.

Methods: We retrospectively assessed outcomes of 3 open cohorts of Māori schoolchildren receiving different interventions: Eastern Bay rural Cohort 1, mean deprivation decile 9.80, received school-based sore-throat programs with nurse and general practice (GP) support; Eastern Whakatane township/surrounds Cohort 2, mean deprivation 7.25, GP management; Western Bay Cohort 3, mean deprivation 5.98, received predominantly GP care, but 3 highest-risk schools received school-based programs. Cases were identified from ICD10 ARF-coded hospital discharges, notifications to Ministry of Health, and a secondary-prevention penicillin database. Primary outcomes were first-presentation ARF cohorts' incidence preintervention (2000–10) and postintervention (2011–18) with cases over annual school rolls' Māori students-year denominators.

Results: Overall, ARF in Maori schoolchildren declined in the cohorts with school-based programs. Cohort 1 saw a postintervention (2011–18) decline of 60%, 148 to 59/100,000/year, rate ratio (RR) = 0.40(CI 0.22–0.73) $P = 0.002$. Males' incidence declined 190 to 78 × 100,000/year RR = 0.41(CI 0.19–0.85) $P = 0.013$ and females too, narrowing gender disparities. Cohort 3 ARF incidence decreased 48%, 50 to 26/100,000/year RR = 0.52(CI 0.27–0.99) $P = 0.044$. In contrast, ARF doubled in Cohort 2 students with GP-only care without school-based programs increasing 30 to 69/100,000/year RR = 2.28(CI 0.99–5.27) $P = 0.047$, especially for males 39/100,000/year to 107/100,000/year RR = 2.71(CI 1.00–7.33) $P = 0{\cdot}0405$.

Conclusions: School-based programs with indigenous Māori health workers' sore-throat swabbing and GP/Nurse support reduced first-presentation ARF incidence in Māori students in highest-risk settings.

Key Words: Acute rheumatic fever, indigenous, Māori, gender, school-based program

(*Pediatr Infect Dis J* 2020;39:995–1001)

In 2018, the World Health Organization recognized acute rheumatic fever (ARF) and its frequent sequela rheumatic heart disease (RHD) as global preventable public health priorities in low- to middle-income countries, and marginalized indigenous communities in high-income countries.[1–3]

From 1993–2009, New Zealand's (NZ) ARF incidence rose in indigenous Māori and Pacific peoples while declining in NZ Europeans (Europeans).[4,5] Māori men and women with RHD die 14–17 years earlier than those without Māori, and 22 years before Europeans with RHD.[6] Eastern Bay of Plenty (Eastern Bay) experiences high Māori RHD admissions of 56/100,000/year (rate ratio = 14 cf. NZE) and RHD-related deaths 6.8/100,000/year (rate ratio = 26), of whom 36% are in late teens to forties: (Beharry, Ingram-Seal, Malcolm "RHD 2005-9" Paediatric Society NZ, Scientific Meeting 2011). Inadequate access to healthcare for Māori is well documented. Strategies to improve access include increasing Māori health provision of services, mainstream improvements, and waiving general practice (GP) primary care fees for children 6–13 years in 2015.[7–10]

School-based sore-throat management for ARF prevention was compared with standard GP cares in an Auckland, New Zealand, randomized trial 1998–2001, aiming to prevent ARF. The ARF incidence reduction (21%) appeared limited by sibling group A streptococcal (GAS) cross-transmission within households.[11] However, subsequent meta-analysis suggested 60% benefit.[12] An enhanced South Auckland school-based program serving 80%–90% Māori and Pacific students concluded that "school-clinic sore-throat-management"[13,14] "can reduce first-presentation ARF approximately 60%."[15] "Reducing a striking health inequality" headlined an editorial referring to successful ARF incidence reduction by school-based sore-throat clinics in Navajo and Papago, Arizona tribes, and Ngati Hine, Whangaroa, NZ.[16] Education and health-delivery collaborate well in New Zealand Schools. Schools are community hubs for dental, psycho-social, and nutrition support, as well as for sport.

The Ministry of Health (Health Ministry) initiated a National ARF Primary prevention program (RFPP) 2012–17 with 3 objectives: increasing ARF awareness, reducing household crowding, and improving priority communities' access to streptococcal throat infection treatment.[17] "National" evaluation 2012–16 using discharges showed a 28% decline in all-age ARF incidence. Evaluation of school-based sore-throat service for 5–12 year-olds compared Education decile 1–3 ARF notifications estimating 23% (CI 6%–44%) effectiveness nationally and 46% (CI 16%–66%) in South Auckland.[18]

Accepted for publication May 5, 2020.
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The authors have no funding or conflicts of interest to disclose.
D.L is deceased.
Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (www.pidj.com).
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ISSN: 0891-3668/20/3911-0995
DOI: 10.1097/INF.0000000000002770

Before this study, the Bay's District Health Board reported a very high Eastern Bay ARF incidence in 5–14-year-old Māori schoolchildren 2003–07: Kawerau, 112/100,000/year; Opotiki, 165/100,000/year; Whakatane, 115/100,000/year; and rural Murupara, 258/100,000/year.[19] Almost all Eastern Bay surpassed the ARF incidence threshold of 50/100,000/year for school-based prevention in the Heart Foundation's 2009 Guideline.[20] Western Bay ARF incidence was lower, 23/100,000/year in Western Bay, and it was 34/100,000/year in Tauranga.[19]

The reported ethnicities of those with Rheumatic fever in the Bay 2003–07 were Māori 86.9%, Pacific 4.6%, and European 6.9% with Māori children's ARF rate ratio of 21 compared with non-Māori.[19] New Zealand Māori and Pacific children ARF rates were 40–100/100,000/year compared with European 1/100,000/year.[21,22]

The Health Board supported primary prevention in schools, initially Eastern Bay focused in high Māori, high deprivation school settings after visits from Helen Herbert, Ngati Hine and Sandra Innes-Smith's advocacy.[23] Four primary prevention school-based programs commenced 2009–2012 (mid-January 2011) in Eastern Bay's highest ARF incidence areas, for tribal areas of Whakatohea and Ngai Tai 2009, Tuwharetoa ki Kawerau 2010, Ngai Tuhoe 2011, Ngati Manawa and Ngati Whare 2012. Regional swabbing data were collected, and regular quality assurance was maintained. The divergence of regional and national evaluations of RFPP were imperatives for Bay-wide RFPP evaluation.

MATERIALS AND METHODS

Setting

The Bay of Plenty (the Bay) occupies NZ's north-eastern coast. The population is 226,530 people, with 27% younger than 20 years, and ethnicities of 26% Māori, 2% Pacific, and 67% European.[24] The Western and Eastern Bay have different demographics. The Western Bay (Tauranga City and Western Bay Districts) has three-quarters of BOP residents and 56% of BOP Māori (who make up 20% of Western BOP population). Within the larger rural Eastern Bay, Māori comprise 40% of Whakatane (the main town), and 60% of Kawerau and Opotiki populations. Western Bay has areas of deprivation, whereas rural Eastern Bay has homogeneous deprivation, as has Whakatane to a lesser extent (see Figure, Supplemental Digital Content 1; http://links.lww.com/INF/E27).[24]

This retrospective study evaluated the effectiveness of school-based programs, on first-presentation ARF incidence in Māori 5–14 year-olds in 3 school-age cohorts before 2000–2010 and after exposure to cohort interventions 2011–18. All cohorts had public health promotion and usual GP care with Health Ministry's intensified program.[17]

The 3 geographically defined cohorts were numbered 1 to 3 East to West. The first cohort had school programs in all schools, in addition to GP care. A second nearby cohort had none and informed the study whether GP-alone care was as effective, and a third cohort had 1 small school-based program and mainly GP care. The number in each open cohort was established from Ministry of Education annual individual school and regional school rolls, aggregated as school-year denominators for this study.[25] Program cost-effectiveness was also assessed.[17]

The child's school location determined the child's cohort (not residence). Ministry of Education (Education) enrolment parental data inform the school rolls, students' ethnicities, deriving Education deciles for equity funding of schools. They utilize 5 demographics common to NZ Deprivation Deciles. Education deciles are unfortunately numbered inversely to deprivation deciles, such that a child from a socioeconomically challenged crowded household may live in NZDep10 (deprivation) and attend an Education decile 1 school (see Figure, Supplemental Digital Content 1; http://links.lww.com/INF/E27).

Cohorts' Interventions and Recruitment

Cohort 1: **School-based programs with GP support:** All 26 Far Eastern Bay rural schools with 91% Māori student rolls (3748 Māori students) were served by 4 adjacent prevention programs commencing 2009 to 2012, midpoint January 2011. The mean residential deprivation is 9.8[23] All programs were staffed by indigenous Māori Community Health Workers and managed by 3 Māori health providers and 1 primary health alliance, with 1 part-time Registered Nurse Lead.

Intervention: Term-time throat swabs were offered twice weekly for students' self-declared sore throats during classroom visits by Community Health Workers. They gained 96% parental consent and student assent. GPs provided prescriptions for GAS-positive swabs, usually once-daily amoxicillin for 10 days.[13,14] In addition, nurses swabbed 2 high-school clinics' self-presenting students with sore throats, treating under standing-orders.

Cohort 2: **GP management without school-based programs:** GPs served 4369 Māori students, attending 19 schools with 54% Māori roll in and near Whakatane, Eastern Bay's largest town with 8/13(62%) localized high deprivation 9–10 areas; mean, 7.25.

Cohort 3: **GP management with a limited school program**: Western Bay's 7528 Māori students were 29% of school rolls, with heterogeneous residential deprivation 2–10; mean, 5.98. (Deprivation 8–10 occurs in 17/56 (30%) Western areas).

A Māori health provider served 3/17 Education decile 1–3 schools, including 805 students, with 48%, 55%, and 75% Māori school rolls from 2011.

Case ascertainment: To derive all school-age first-presentation cases of ARF hospital discharges were sought with specified ICD codes I00.0–I02.9, "mandatory" ARF Notifications to Health Ministry and a database of those on ARF secondary Benzathine Penicillin prophylaxis.[26] Initially, all-age cases, then 5–14 year-olds of all ethnicities, and then Māori 5–14 year-olds were identified. On individual electronic and paper clinical case-note scrutiny, standardized case definitions were applied from NZ Heart Foundation case definitions.[27] Those fulfilling definite, probable and possible diagnostic criteria with onset while living in the Bay (2000–2018) were accepted. To assess possible diagnostic shifts, echocardiographic severity[27] and case certainty were audited. Ethnicity was self/family identified for cases, then the Health Ministry single prioritization was applied.[28,29] Each case's residential deprivation decile was noted.[23]

Exclusions and Inclusions: Cases were excluded if attending school outside the Bay. If resident in one area, attending another area's school, cases were included in their school's cohort.

Denominators for Rate Analysis and Rationale

ARF incidence in BOP, NZE, Māori students age 5–14 years was calculated for 2000–2018 using confirmed cases over cumulative annual Education roll-derived school populations (student-years).[25] The rationale for not using Education deciles 1–3 as in the National school program evaluation follows.[18] Education deciles 1–3 were 1 of 3 criteria for the Health Ministry funded school programs.[17] In the Bay, the Education decile 1–3 schools' ethnic composition varies and the proportion of all Māori attending them. In the 3 Education decile 1–3 schools with RFPP in Cohort 3, their rolls were 55% Māori, 7% Pacific, and 29% European students (Table 1).

The limitations of analysis comparing 5–14 year "all ethnicity cohorts" or "lower decile schools" as a proxy for ARF risk are apparent from the table: Contemporaneously comparing

TABLE 1. Comparisons of Cohorts 1–3, Their Education Deciles 1–3 and 1–10, Ethnicities of Students, and Relationship to NZ Residential Deprivation NZDeps

	Cohort 1 East Rural	Cohort 2 East Whakatane	Cohort 3 West
Education decile 1–3 proportion of schools	25/26 (96%)	7/19 (37%)	17/68 (25%)
Māori % of roll in Education decile 1–3 schools	(80%)	(77%)	(55%)
Percentage school-age Māori outside Education decile 1–3	9	68	71
Education decile 1–10 Māori: European roll ratio	91/7	54/41	29/57
Mean NZ deprivation decile of cohorts' census areas	9.80	7.25	5.98

whole cohort ARF rates would be confounded by varying proportions of often affected Māori to rarely affected European students. Also, without ethnic-specificity, an intervention achieving "Western Cohort 3 Māori school-age ARF 30% decrease" appears limited as "Cohort 3 West's 13% decrease." Hence, to monitor school intervention outcomes (ARF rates), Māori 5–14 year denominators were derived from Education roll data. Bay-wide rates for all age, school-age Māori, Pacific, and European have been submitted for publication.[30] Here, parallel cohort 1–3 Māori outcomes in differing economic settings can be compared pre–post intervention, potentially guiding appropriate service models.

Statistical methods: The BOP Māori 5–14 year-old cohort incidences 2000–2010, 2011–15 (for comparison with contemporaneous studies, see Table, Supplemental Digital Content 2; http://links.lww.com/INF/E28) and 2011–18 were calculated. Rate ratios and 95% CI, were estimated using StataCorp Texas Statistical Software: Release 14.2, 2015.

GAS Pharyngeal point prevalence was assessed in a cohort 1 subset, EBOP Kawerau schools, before sore-throat swabbing began (May 2010) and after 3 and 4 program-years in August 2013 and 2014, when Kawerau's skin infection program commenced providing hygiene education, first-aid products, and antiseptics with few antibiotics required.[31]

Cost-effectiveness was evaluated using pre–post program effectiveness, and BOP staff/laboratory/pharmaceuticals/school programs costs/student/year, having confirmed "included costs" within the Interim RFPP evaluation model of the Institute of Environmental Science and Research (ESR).[17] Costs were applied to the report's table, deriving cost/ARF case prevented, RHD death averted, and quality-adjusted life-year QALY gained, then compared with funding thresholds.[17]

Ethics: This retrospective cohort study adheres to "Ethical Guidelines for Observational Studies, NZ Health Disability Ethics Committee Standard Operating Procedure exemption provisions 2014" and to "NZ, HRC Guidelines for Researchers on Health Research Involving Māori 2010." Kawerau GAS prevalence studies obtained parental swabbing-consent and ethics approval NZ/1/77C3019.[32] This study report aligns with STROBE guidelines.

RESULTS

The 3 sources identified this study's 128 Māori students 5–14 years of age with first presentation ARF (see Fig. 1).

ARF Trends by Cohort

Cohort 1: ARF incidence in the most deprived Eastern Māori school-based program students 5–14 years of age, reduced by 60% comparing 2000–10 with 2011–18 (Table 2).

Cohort 2: ARF incidence in Eastern Whakatane township and surrounding area Māori students' rates doubled with GP-surgery-alone care, without school-based programs, until commenced in 5/19 schools in 2018. Cases were primarily from 5 lower Education decile primary schools with high Māori rolls, most frequently attending intermediate school (11–12 year-old pupils, 52% Māori, Education decile 4, also high schools from high-NZ Deprivation areas).

Cohort 3: ARF incidence for Māori reduced in less deprived Western Bay by 48%, comparing 2000–10 with 2011–18 (Table 2).

ARF Trends by Gender

Within Eastern Bay School-based programs, ARF incidence in both genders substantially declined from 2000–2010 to 2011–18 with Māori 5–14-year-old boys decreasing 59% from 191 to 78/100,000/year, and, Māori girls 63% from 104 to 38/100,000/year. (see Fig. 1, Table 3). In adjacent cohort 2, the incidence in boys' rate rose from 39/100,000/year to 107/100,000/year without school-based programs. In Cohort 1 (despite greater rurality and deprivation), the ARF incidence in Māori 5–14 year-old boys served by school programs from 2011 to 2018 was 27% less than for boys receiving GP-only care in cohort 2.

Case-definition consistency, echocardiographic severity,[13] and case diagnostic certainty were stable. However, incomplete/delayed Eastern Bay echocardiographic access, 87% in 6 months 2000–2010, potentially lowered preintervention ARF diagnoses, lessening intervention effects.

Pharyngeal GAS Prevalence trends: In Eastern Bay (Kawerau) winter pharyngeal GAS point-prevalence declined from 22% (CI 14–33) to 15% (CI 6–29) then 8% (CI 4–15) (2010/2013/2014, respectively) ($P = 0.009$), paralleling the decline in ARF incidence observed with school sore-throat-swabbing programs.[32,33] Annual Eastern Bay Primary Health Alliance reports show seasonality with more winter GAS positive sore throats.

Cost-Benefit: Applying direct school-based program calculated costs of $165/child/year to Interim National RFPP Evaluation cost-benefit tabulations, using 60% effectiveness from 2011–2018, derives $55,064/ARF case prevented, $415,342/RHD-related death averted, and $13,488/QALY gained.[17]

DISCUSSION

Key Findings: The Impact of School-Based ARF Prevention Programs

ARF incidence in Māori 5-14 year-olds was reduced by 60% from 148 (CI 110.18–195.71) to 59 (CI 31.41–100.89)/100,000/year with school-based programs in high Māori population schools in the highest-deprivation rural areas of the Bay. Eastern Bay school-based ARF prevention was as effective for rural town Māori as it was initially for South Auckland's suburban Pacific (2/3) and Māori (1/3) population.[15] Eastern school-based program effectiveness was sustained; ARF incidence in Māori declined further during 2016–18, whereas nationally ARF incidence in Pacific peoples rose since 2015, plateauing for Māori. Our evaluation[15] finds school-based programs substantially more effective and cost-effective than Health Ministry-Environmental Scientific Research[17] and "National evaluations" predicted[18] for regions outside metropolitan Auckland, and for rural Māori with high ARF case concentration. Bay school-based programs were found to be more

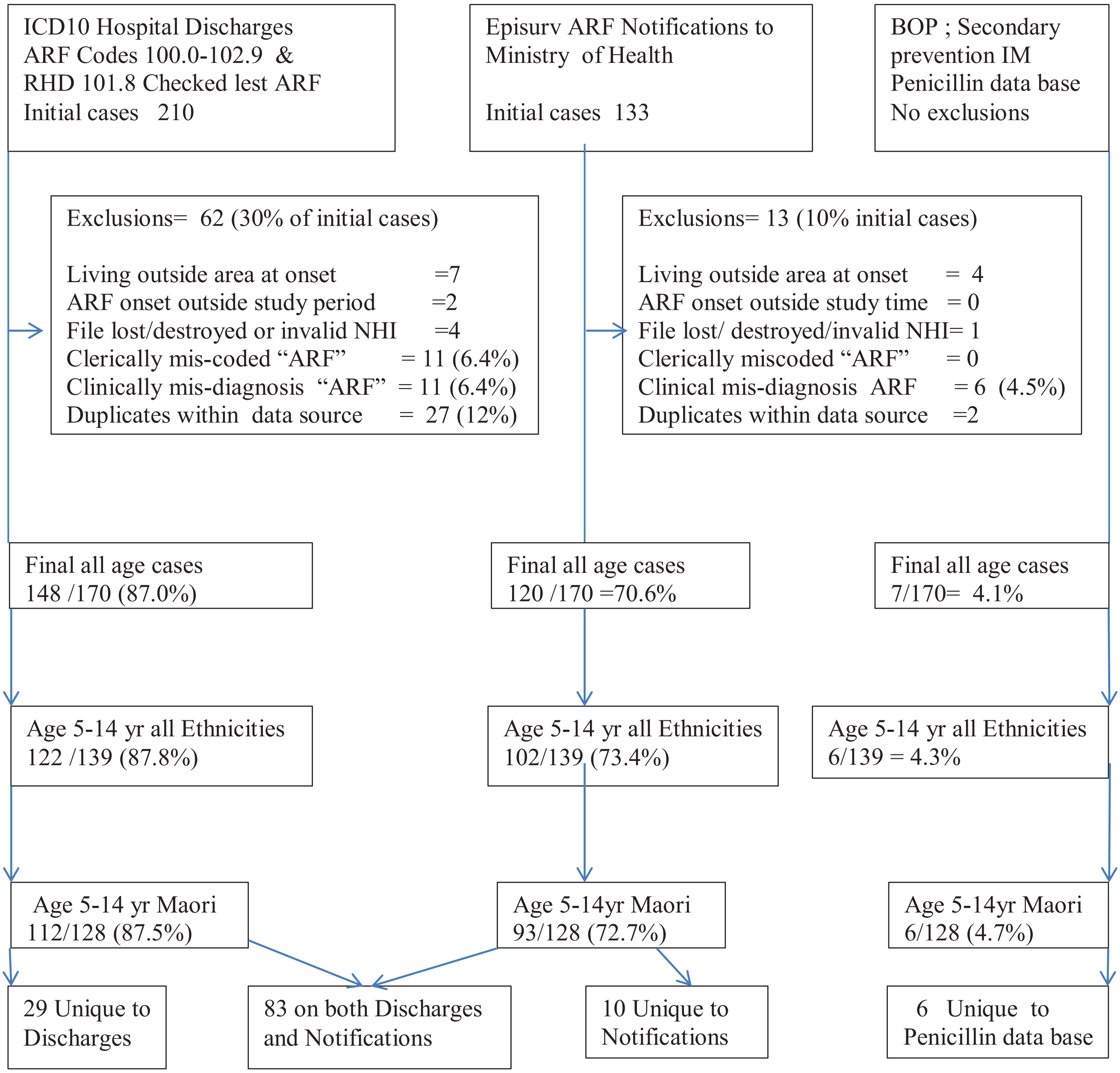

FIGURE 1. First presentation ARF, in all ages, and ethnicities, and onset in Bay of Plenty 2000–18; initial and final "ARF case definition scrutinized" cases by data source, and exclusions.

effective than GP-alone services, comparisons suggested on the "National program evaluation."[18,34]

GP-alone sore-throat management had limited reach without school-based programs. In Whakatane township and surrounds (cohort 2) with areas of similar Māori school rolls and deprivation, ARF incidence in Māori 5–14 year-olds doubled (2011–18). Rates surpassed the suggested school program threshold 50/100,000/year[27]; students share infectious GAS at school and home[11] while bussing between ARF rural intervention areas and town and vice versa. Students present with ARF at primary and middle-decile intermediate school and colleges. Families consent to accessible school programs. Booking and accessing after-school GP-swabbing is harder.[31]

Western Bay intervention was mainly primary care, with swabbing at 3 schools. Where ARF in affected Māori is scattered from decile 1 to 10, this mixed model shows some success for Māori. It saw a smaller decline in ARF for Māori 5–14 year-olds of 48% improving on lower initial incidence.

While acknowledging the limitation of comparing contemporaneous cohorts with variable deprivation, cohort 1 boys have better outcomes than cohort 2 Māori boys from more affluent settings but without school programs. Despite under-intervention in cohort 2 while Māori ARF incidence climbed there,[5] Bay-wide ARF incidence in all 5–14 year-olds[30] and in Māori 5–14 year-olds declined. Bay-wide ARF health promotion preceded increased public understanding and increased GP throat swabbing.[35]

We estimate that Eastern Bay school-based programs prevented 23 ARF cases, Western Bay care prevented 9, and if

TABLE 2. BOP Māori 5–14 Years ARF Rates, Cohorts Compared; Rate Ratio 2000–10 vs 2011–18.

BOP ARF rates for Māori 5–14 yr/100,000/year cohort and deprivation	Rate 2000–10 cases/student years	Rate 2011–18 cases/student years	2000–10 vs 2011–18 Rate ratio*, confidence interval, and P value
Cohort 1 Eastern Bay rural school-based intervention with GP support Deprivation decile mean 9.80	50/33,682 = 148.44	13/22,035 = 59.00	RR 0.3958 CI 0.2151–0.7283 P = 0.0020
Cohort 2 Eastern Bay Whakatane town and surrounds; GP-only care Deprivation decile mean 7.25	9/29,922 = 30.08	14/20,432 = 68.52	RR 2.2800 CI 0.9871–5.2666 P = 0.0472
Cohort 3 Western Bay; GP care plus programs in 3/58 schools Deprivation decile mean 5.98	28/55,792 = 50.19	14/53,318 = 26.26	RR 0.5226 CI 0.2751–0.9925 P = 0.0436

*To derive rate ratios (Stata 14.1), cases/noncases, exposed to interventions/without interventions are compared.

Whakatane town and surrounding area school-based programs had been initiated, 9 fewer cases might have occurred from 2011 to 18.

International

School-based treatment of symptomatic GAS pharyngitis in China lowered GAS prevalence and subsequent GAS pharyngitis.[36] Costa Rica's ARF incidence declined, using Benzathine-penicillin injections for clinical sore throats, achieving RHD control in resource poor settings.[37] Cuba's 5–14 year-olds' ARF incidence declined from 23/100,000/year to 2/100,000/year (1986–2002) after implementing comprehensive streptococcal throat ARF/RHD programs, and community education.[38] Baltimore, MD, USA "comprehensive-care programs" closed the gap between Afro-Americans' ARF rates and whites' in the 1970s.[39]

Group A Strep Prevalence, Sore Throats, Skin, Covert, and Overt Pathways to ARF

Same-season pharyngeal GAS point-prevalence declined paralleling ARF incidence declines, both in Eastern Bay and Auckland school-based sore-throat programs declining further when skin sepsis programs began.[15,31,32] Eastern Bay skin sepsis admissions have also declined.[40–42] Skin sepsis RFPP program coverage broadened to all Eastern Bay 2020.

Successful U.S. school ARF programs also observed lessening GAS prevalence and transmission. They also identified "GAS decline-carryover" to subsequent years,[33] which possibly confounded NZ's 2012–16 "effectiveness analysis" comparing ARF cases during, and following school programs' discontinuation.[18]

"Stable" GAS throat carriage has been described as enigmatic,[43] sometimes progressing to clinical infection.[44] Of new GAS acquisitions, 65% are asymptomatic but immunologically significant.[45,46] Students' self-declared sore throats do indicate ARF risk when GAS-positive. While previously considered problematic, this study confirms them as a sufficient "overt" threshold for ARF prevention.[47]

Implications for Ethnicity and Deprivation Thresholds of School Programs

We suggest more nuanced targeting. Western Bay cohort 3 ARF incidence declined, including targeting 3 schools with 55% Māori, 7% Pacific, and 29% NZE students. ARF rates doubled in Cohort 2 where students most frequently attended intermediate, (52% roll Māori 11–12 years of age, Education decile 4), and 4 decile 1–3 schools with 75% Māori rolls, some from high-NZ Deprivation areas. Once (not twice) weekly sore-throat swabbing began in 5 schools including intermediate in April 2018. Targeted free pharmacy sore-throat swabbing for 4–19 year-olds began in November 2018. Both innovations require evaluation.

Implications of Gender and Cost for School-Based ARF programs

We identified Bay-wide male over-representation in ARF presentations, underlying higher male GAS pharyngeal prevalence and lower sore-throat presentations.[30] Some interventions increase inequities. It is encouraging that school-based programs narrow long-standing gender and ethnic inequities. Male Māori students

TABLE 3. BOP Māori 5–14 Years Cohort ARF Rates by Gender, Compared Rate Ratio 2000–10 vs 2011–18.

BOP ARF rates for Māori 5–14 yr/100,000/year	Rate 2000–10 cases/student years	Rate 2011–18 cases/student years	2000–10 vs 2011–18 Rate ratio*, confidence interval and P value
Cohort 1 Deprivation decile mean 9.80			
Males Eastern Bay Rural School-based intervention with GP support	33/17,317 = 190.56	9/11,582 = 77.71	RR 0.4056 CI 0.1942–0.8473 P = 0.0130*
Females Eastern Bay Rural School-based intervention with GP support	17/16,364 = 103.89	4/10,453 = 38.27	RR 0.3672 CI 0.1236–1.0911 P = 0.0602
Cohort 2 Deprivation decile mean 7.25			
Males Eastern Bay Whakatane town and surrounds; GP-only care	6/15,246 = 39.35	11/10,323 = 106.56	RR 2.7121 CI 1.0033–7.3310 P = 0.0405*
Females Eastern Bay Whakatane town and surrounds; GP-only care	3/14,660 = 20.46	3/10,110 = 29.67	RR 1.4502 CI 0.2928–7.1834 P = 0.6470
Cohort 3 Deprivation decile mean 5.98			
Males Western Bay GP care plus program in 3/58 schools	20/28,728 = 69.62	10/27,323= 36.60	RR 0.5248 CI 0.2457–1.1210 P = 0.0903
Females Western Bay GP care plus program in 3/58 schools	8/27,065 = 29.56	4/25,995 = 15.39	RR 0.5202 CI 0.1567–1.7273 P = 0.2773

* To derive rate ratios (Stata 14.1), cases/noncases, exposed/without interventions are compared.

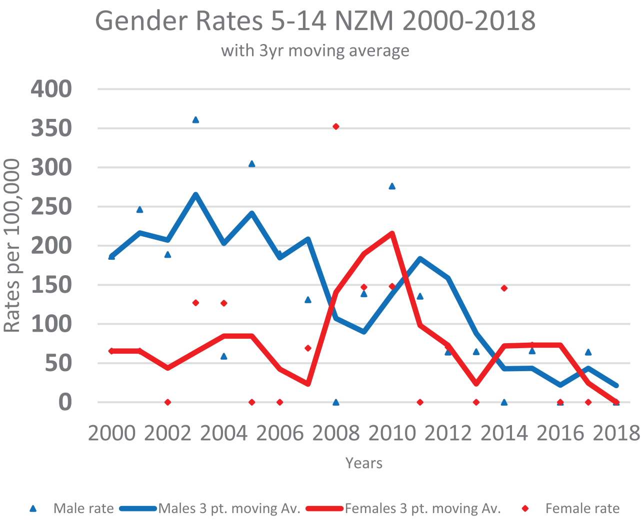

FIGURE 2. Cohort 1 first-presentation ARF rates in Māori 5–14 years by gender; 3 year moving average.

ARF incidence declined towards female Māori students lowering incidence (Fig. 2).

School-based programs in BOP are cost-effective investments, swabbing twice not thrice weekly, costing less/child than Auckland's.[15,17,31] BOP's cost $13,488/QALY gain is relevant to District Health funders as less than Pharmac's and WHO's funding thresholds.[17] Similar evidence of declining regional ARF is emerging from Tairawhiti, Hawkes Bay,[48] and Lakes Districts programs. Developing countries did estimate lower costs,[49,50] with strategic savings[37,51] when they too considered school-based strategies.

Implications for methodology: We derived more accurate ARF rates with more complete numerator case-capture by utilizing reliable multisourced scrutinized data rather than using notifications alone.[30] Ethnic specific denominators better inform Māori school-age rates, trends, and effectiveness than Education decile 1–3 proxies. Public health professionals and Health Ministry might utilize them nationally to reappraise school programs' effectiveness.

Context, meaning, future research: Both the East-West Bay and Male:Female ARF gradients for Māori are partly explained by deprivation[23] and health service design and delivery. Cultural safety analysis acknowledges patient lives' complexities and reflects on institutional inequities, applies quality improvement to services, and gives insight to interpersonal and professional conduct.[10,52] Meanwhile, for some disparities, robust public health evidence, cultural safety steps and pathways are emerging. Future applied research might well explore the outcomes of their application.

CONCLUSION

Bay-wide ARF disparities are substantially lessened by interprofessional primary health networks with indigenous Māori provider school-based programs partnered with nursing, and GP support. They are well-accepted, accessible, and effective. Our findings strengthen the evidence for school-based programs for highest-risk Māori communities and "targeted" within areas of variable deprivation.

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