Is dengue a disease of poverty? A systematic review

Kate Mulligan¹, Jenna Dixon², Chi-Ling Joanna Sinn², Susan J. Elliott³

¹Toronto Public Health, Toronto, Canada, ²School of Public Health and Health Systems, University of Waterloo, Canada, ³Geography and Environmental Management, University of Waterloo, Canada

Policy prescriptions for combating dengue fever tend to focus on addressing environmental and social conditions of poverty. However, while poverty has long been considered a determinant of dengue, the research evidence for such a relationship is not well established. Results of a systematic review of the research literature designed to identify and assess the current state of the empirical evidence for the dengue–poverty link reveal a mixed story. Of 260 peer-reviewed articles referencing dengue–poverty relationships, only 12 English-language studies empirically assessed these relationships. Our analysis covering various social and economic conditions of poverty showed no clear associations with dengue rates. While nine of the 12 studies demonstrated some positive associations between measures of dengue and poverty (measured inconsistently through income, education, structural housing condition, overcrowding, and socioeconomic status), nine also presented null results and five with negative results. Of the five studies relating to access to water and sanitation, four reported null associations. Income and physical housing conditions were more consistently correlated with dengue outcomes than other poverty indicators. The small size of this sample, and the heterogeneity of measures and scales used to capture conditions of poverty, make it difficult to assess the strength and consistency of associations between various poverty indicators and dengue outcomes. At present, the global body of eligible English-language peer-reviewed literature investigating dengue–poverty relationships is too small to support a definitive relationship. We conclude that more research, particularly using standardized measures of both outcomes and indicators, is needed to support evidence-informed policies and approaches.

Keywords: Dengue, *Aedes*, Poverty, Systematic review, Evidence-informed decision-making

Introduction

Dengue fever is frequently called a disease of impoverished places and ‘is most closely associated with poor populations’.¹ The World Health Organization classifies dengue fever as one of the world’s 17 neglected tropical diseases (NTDs) — diseases that serve as ‘prox(ies) for poverty and disadvantage’² — and prescribes population-targeted interventions to manage dengue in impoverished and marginalized communities. The argument in favour of socioeconomic development increasing dengue transmission was buttressed by decline of dengue in Europe and the USA as prosperity in these regions increased.³

Yet evidence of endemic dengue in wealthy households, neighbourhoods, and cities appears to run counter to the categorization of dengue as a disease of poverty. Indeed, Gubler has argued that the large increase in global prevalence was actually driven by economic growth in the post-WWII era.⁴ Global

trends including widespread urbanization and a growing middle class further suggest that the mosquito-borne virus will be of increasing relevance for non-poor people and places. In addition to these important socioeconomic influences seemingly underlying the spread of the disease, fewer than 4% of published dengue research articles are from social scientific and interdisciplinary disciplines (rather than biomedical) — a clear gap in the literature.⁵

The debate over dengue’s association with poverty takes place in the context of a growing research and policy agenda regarding the social determinants of health: the economic, environmental, and social conditions that ‘shape the health of individuals, communities, and jurisdictions as a whole’.⁶ Research into the social determinants of health interprets poverty in several ways: in terms of the daily living conditions of individuals and communities (social, ecological, and economic environments); inequalities in the distribution of power, money, and resources (a comparative measure of poverty as inequity); and differences in individual and community-level socioeconomic characteristics (levels of education, literacy, income, and so on).⁷

Correspondence to: J. Dixon, School of Public Health and Health Systems, University of Waterloo, Waterloo, Ont., Canada. Email: jenna.dixon@uwaterloo.ca

At the same time, there has been growing concern for emerging and re-emerging infectious diseases, particularly in poor and urbanizing areas.^{8,9} At the global level, the Millennium Development Goals (MDGs) represented international understanding that poverty reduction programs should address the social determinants of infectious diseases, with a particular emphasis on HIV/AIDs, malaria, and tuberculosis. Not long after world leaders at the United Nations adopted the Millennium Declaration in 2000, policy prioritization efforts emerged to draw attention to those infectious diseases not mentioned by the MDGs. These lobby efforts crystallized at the global level under, *inter alia*, the WHO's NTD programs, which have become a locus for global initiatives to target funding to diseases that have been under-prioritized for research and action.^{2,10,11}

Dengue is the most rapidly advancing vector-borne disease in the world and a major global public health issue, particularly in tropical and sub-tropical environments. Up to 40% of the world's population — 2.5 billion people in over 100 countries — live in areas which put them at potential risk of infection, and between 50–100 million infections are reported each year.^{12–15} Additionally, recent estimates suggest that the global burden of dengue may be dramatically higher than this conservative and widely cited estimate. While the disease burden is predominantly located in low-to-middle income countries, the association with poverty remains in question.¹⁶

Mosquitoes transmit the dengue virus, and its epidemiology and transmission characteristics should be interpreted in relation to poverty in the context of the biology and ecology of *Aedes aegypti*. This subgenus serves as an excellent dengue vector as it is highly susceptible to the virus, prefers human blood, is a daytime feeder, its bite goes largely unnoticed by humans and often bites several people in a short period of time.¹⁷ In the Americas throughout the 1950s and 1960s, dengue was effectively eliminated through *Ae. aegypti* eradication program (namely, eradication of open source breeding sites). Yet these successes backtracked in the 1970s as rapid urbanization took place and the eradication program was ended. The mosquito thrives in urban environments, breeding in stagnant water that often accumulates in discarded man-made containers (e.g. truck tires, pots, non-biodegradable plastic containers).^{4,17} Thus, while many elements explain the increasing rates and severity of dengue on a global scale (globalization/international travel, urbanization, increasing global population, climate change),^{3,4,17,18} vector control methods that confront stagnant water, such as having piped water so that houses need not store water, have been suggested as the best strategy to control the expansion of dengue.¹⁹

Understanding the academic contribution to the debate over dengue's association with poverty is important for evidence-informed decision-making. Evidence-informed decision-making aims to ensure that the best available research evidence gathered through intentional and systematic processes is brought into the policy process and guides decisions.²⁰ This in turn has important implications for dengue control initiatives at different policy and geographic scales. At local levels, public health policy and practice have a clear interest in understanding the socio-ecological determinants of dengue in order to decide how, where and to whom disease control initiatives should be targeted. Globally, NTD policy initiatives have increasingly linked globally-neglected diseases with poor populations and places, and argue for population-specific, rather than disease-specific, interventions.^{2,21} At national and regional levels, particularly in developed and rapidly developing contexts, policy actors and institutions also risk de-prioritizing the disease as one irrelevant to wealthy and middle-income communities.^{22,23}

Given the debates over the contributions of poverty to the distribution and diffusion of dengue, the noted gaps in the research literature, the policy impetus given to these debates by global NTD initiatives, and the relevance of findings for control initiatives for this rapidly-spreading disease, we carried out a systematic review of the literature to assess the empirical evidence for a dengue–poverty link. Although dengue's characterization as a disease of poverty may include the degree to which the disease can be construed as poverty-promoting (i.e. incurs economic costs or burden of illness), this review focuses on poverty as a determinant, rather than an outcome, of the incidence or prevalence of dengue infection. While a small and heterogeneous sample poses clear limitations to analysis (discussed later in this article), the exercise remains worthwhile as a first step toward identifying not only the (limited) evidence base for constructions of dengue as a disease of poverty, but also which poverty indicators have been associated with dengue in the literature to date.

Methods

We systematically reviewed the research evidence supporting the characterization of dengue as a disease of poverty. Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines,²⁴ we systematically searched the English-language research literature into dengue–poverty connections. We searched six electronic databases across the biomedical sciences, physical and natural sciences, social sciences, and international health disciplines (MEDLINE, EMBASE, Web of Science — Social Sciences Citation Index, Web of

Science — Science Citation Index, Popline, and Global Health) without restrictions on time period or geographic scope. Measures of dengue and vector rates were captured using ‘dengue’ and ‘Aedes’. Terms used to retrieve articles relating to poverty measures or their indicators included: ‘poverty’, ‘income’, ‘social class’, ‘population density’, ‘economics’, ‘socioeconomic factors’, ‘housing’, ‘employment’, ‘unemployment’, ‘public health practice’, and ‘community health services’.

All types of quantitative studies that empirically assessed the relationship between poverty or its indicators and dengue or *Ae. aegypti* vector rates, using original data analysis or novel analysis of secondary data, were eligible for inclusion in this review. However, we excluded studies if their authors did not link possible indicators (for example, housing condition) with poverty or socioeconomic status in any section of the article. We also excluded studies that assessed dengue risk without directly measuring the presence of vector mosquitoes or dengue cases (e.g. risk indices based on presence of household water containers). We further excluded studies of the economic impact of dengue (e.g. burden of disease studies). Further, while the access of health-care services and follow-up care are important in controlling dengue post-infection, this review is only focused on determinants of initial infection. Thus, the location of household in relation to health care was not a focus of this study. Only full articles that were peer-reviewed and published (or in-press) were included. The search followed PRISMA guidelines for reporting in systematic reviews²⁴ and the model used by Lund *et al.*²⁵ in their review of the associations between poverty and common mental disorders.

The initial electronic search and manual search of the reference lists yielded 260 unique articles. All titles and abstracts of identified articles were independently assessed for relevance by two reviewers (Cohen’s kappa = 0.77, good inter-rater agreement). Full-text articles for 66 potentially relevant abstracts were obtained. A further 53 articles were excluded using the exclusion criteria set out in Fig. 1 (Cohen’s kappa = 0.88, very good inter-rater agreement). At the end of each stage, the two reviewers discussed all discordant or uncertain results until agreement was reached.

Two reviewers independently conducted the quality assessments of articles in the final analysis. Following Lund *et al.*,²⁵ we applied a set of pre-determined criteria based on SIGN50 guidelines. Each study was assigned an overall rating of ‘++’, ‘+’, or ‘–’ based on the number of fulfilled criteria, and the likelihood that any unfulfilled criteria would alter the study’s conclusions. Cohen’s kappa coefficient measured 0.63 for study quality for good

inter-rater agreement. Included studies were described and qualitatively assessed with respect to their potential to contribute to evidence-informed decision making.

Results

A total of 13 articles representing 12 studies were included in the final analysis. Table 1 shows the country of study, measures of dengue and poverty, and basic findings of the studies included in the final review. The majority of studies were conducted in South America (others were undertaken in South-east Asia, North America, and the Caribbean) and were undertaken in urban community settings. The number of eligible studies published per year remained small over the review period (1998–2010).

Measuring poverty

Most of the studies in this body of research used multiple poverty measures in their analyses (see Table 1 for details). These included income, education, housing/living environment (structural), housing/living environment (overcrowding), access to water and sanitation, and socioeconomic status, all of which were measured at either household or area level scales, depending on the study. However, poverty and its indicators were not well defined. Poverty variables were rarely standardized, rendering them difficult to compare among studies. In the majority of studies, poverty variables and their methods of measurement were not explicitly defined or explained. The heterogeneity of poverty indicators and measures pose challenges to assessing the consistency and strength of poverty–dengue associations. Scale, for example, is an important factor: although dengue may be contracted outside the home (making human mobility within and beyond cities and neighbourhoods an important factor in disease transmission),²⁶ few studies investigated dengue–poverty relationships at scales higher than that of the household.

The most commonly used poverty indicators were income and education. Income was measured at the household scale, including family income, relation to poverty line, eligibility for Health Equity Fund, head of household income, and area scale, including mean income, or census tracts where more than half of heads of households earned less than the poverty line of two time minimum wage. Education was measured at the household scale via years of education, literacy years of education of the household head, number in household below primary education level and dengue-related knowledge attitudes and practices. At the area level, education was only measured through years of education.

Despite the importance of having reliable piped water in halting the *Ae. aegypti*-borne viral diseases

Figure 1 Flow of included studies.

such as dengue, only five of the studies measured access to water and sanitation (either at household or area scales). Three of the studies used only socioeconomic status as their poverty indicator (specifically household occupation, neighbourhood social class,

and population per physician, nurse, and hospital bed with a resource distribution/relative wealth index).

Commonly used standardized poverty measures (those that consistently measured the same dimension of poverty and therefore allowed for direct

Table 1 Study characteristics

Author (year)	Braga (2010) ³⁴	Heukelbach (2001) ³⁵	Honório (2009) ³⁶	Indaratna (1998) ³⁷	Ir (2010) ³⁸	Penna (2010) ³⁹	Reiter (2003) ⁴⁰	Siqueira (2004) ⁴¹	Siqueira (2008) ⁴²	Spiegel (2007) ⁴³	Teixeira (2002, 2007) ^{44,45}	Tsuzuki (2009) ⁴⁶
Country studied	Brazil	Brazil	Brazil	Thailand	Cambodia	Brazil	Mexico; USA	Brazil	Brazil	Cuba	Brazil	Vietnam
Poverty indicator	Area (multiples of minimum wage)	Household (family income)			Household (relation to poverty line; eligibility for Health Equity Fund)		Area (mean income)	Area (census tracts where more than 50% of the heads of household earned less than the poverty line of 2 x minimum wage)	Household (head of household income, Area (census tracts where more than 50% of the heads of household earned less than the poverty line of 2 x minimum wage)	Household (family income)	Area (mean household income, Household (self-reported income)	
Education	Household (years of education)	Household (literacy)			Household (years of education, literacy)	Area (years of education)		Area (years of education)	Area (years of education)	Household (years of education of household head, number in household below primary education level)	Household (years of education)	Household (years of education, dengue-related knowledge, attitudes and practices (KAP))
Housing/living environment (structural)							Household (presence of air-cooling system, number of air conditioners, lot size)			Household (house condition)	Household (adequate sewage disposal — household connected to the municipal sewage system or having its own septic tank)	Household (presence of covers on water containers)
Housing/living environment (overcrowding)	Household (persons per room)	Household (persons per room, persons, per house)							Area (housing density)		Area (population density)	Area (typical housing structural type)
Access to water and sanitation	Household (presence of regular water supply)	Household (presence of regular water supply, access to sanitation)						Household (presence of regular water supply — indoor piped water)		Household (self-reported access to regular water supply)		Area (presence of regular water supply)
Socioeconomic status		Household (occupation)	Area (neighbourhood social class)	Area (population per physician, nurse, and hospital bed; resource distribution/relative wealth index)	Household (asset-based principal component analysis — incl. housing condition, ownership of agricultural land, livestock, means of transport, entertainment materials)					Household (self-assessment of economic situation)		Household (household asset ownership)
Dengue indicator												
Vector			Household (<i>Ae. aegypti</i> mean adult density and mean egg density); Agrea (Breteau index — number of <i>Ae. Aaegypti</i> -positive containers per 100 houses)							Household (positive larval inspection reported by vector control technicians)	Area (Premise Index — percentage of all inspected premises with at least one positive breeding site of <i>Ae. aegypti</i> larvae)	Household (<i>Ae. aegypti</i> pupal count)

Table 1 Continued

Author (year)	Braga (2010) ³⁴	Heikelbach (2001) ³⁵	Honório (2009) ³⁶	Indaratna (1998) ³⁷	Ir (2010) ³⁸	Penna (2010) ³⁹	Reiter (2003) ⁴⁰	Siqueira (2004) ⁴¹	Siqueira (2008) ⁴²	Spiegel (2007) ⁴³	Teixeira (2002, 2007) ^{44,45}	Tsuzuki (2009) ⁴⁶
Laboratory test	Household (seropositivity for IgG)	Household (seropositivity for IgG and IgM; DENV type)	Household (seropositivity for IgG and IgM DENV type)	Area (annual records of dengue incidence from Ministry of Public Health)	Household (illness episodes affecting household members during the previous month, perceived serious illnesses during the year preceding the interview)	Area (incidence rate, hospitalization rate)	Household (seropositivity for IgG and IgM)	Household (seropositivity for IgG and IgM)	Household (seropositivity for IgG and IgM)		Household (seropositivity for IgG)	
Clinical case		Household (clinical criteria of acute dengue set by National Health Foundation)										
Self-report			Household (clinical symptoms of dengue-like disease, past dengue episodes)					Household (self-reported dengue, family history of dengue)	Household (self-reported dengue, family history of dengue)			
Dengue–poverty connections	<p>Positive: low/intermediate SES and household overcrowding</p> <p>Negative: low level of schooling with infection in the low and intermediate SES areas</p>	<p>Null: none of the socio-economic variables were predictors for the occurrence of dengue fever</p>	<p>Positive: higher seroprevalence in lowest-income area</p> <p>Null: recent infections in high-, medium-, and low-income areas; spatial distribution of recent infection and mosquito density</p> <p>Negative: higher attack rates in highest-income area</p>	<p>Null: income distribution and disease occurrence (although the dengue case load in 1995 tended to be greater in low-resourced areas, there was no clear, simple correlation)</p>	<p>Positive: asset-based SES (dengue was about twice as common among the poorest than among the rich)</p>	<p>Negative: education and dengue (those with higher education had higher incidence and hospitalization rates)</p>	<p>Positive: absence of air-conditioning, fewer room air conditioning units; absences of air-conditioning; proportional cost of air-conditioning</p> <p>Null: number of room air-conditioners</p>	<p>Positive: low education, low head-of-household income</p> <p>Null: crowding, lack of access to regular indoor water supply</p>	<p>Positive: low income and education</p> <p>Null: dengue cases not restricted to deprived areas</p> <p>Negative: Higher education level</p>	<p>Positive: poor housing quality, self-assessment of economic situation as poor, low family income</p> <p>Null: education, crowding, access to water and sanitation</p>	<p>Positive: Population density</p> <p>Null: mean income, standard of living</p> <p>Negative: higher education level</p>	<p>Positive: inappropriate use of covers on water containers</p> <p>Null: knowledge and socio-economic conditions, dengue knowledge and presence of cover on jars and plastic buckets, socio-economic conditions and presence of cover on jars and plastic buckets</p>

comparisons) included years of formal education and household overcrowding, defined as persons per room or persons per residence. The most common poorly defined poverty measure was the structural condition of housing and living environment. Variables for this indicator ranged widely across studies — from the absence of an air-cooling system to a subjective analysis of house condition.

Measuring dengue

For the most part, dengue indicators were well defined within this body of research. All laboratory measures of serum anti-dengue immunoglobins (IgG or IgM) used commercial enzyme-linked immunosorbent assay kits. Some studies also included additional laboratory tests. Several studies used clinical diagnoses from secondary data sources. Four of the 12 studies used multiple dengue measures; self-reported dengue was recorded in three studies (Table 1).

A number of studies used vector rates (determined from entomological surveys of *Ae. aegypti* pupae or larvae) as a proxy for dengue risk and prevalence, suggesting a connection between high *Ae. aegypti* density and high seroprevalence. However, it is possible for transmission to be maintained at high levels even in situations of low vector density.²⁷ Furthermore, no specific index has been developed for the *Ae. aegypti* adult population that is involved in actual dengue transmission.²⁸ We excluded studies drawing solely on ecological measures of risk (e.g. presence of uncovered water containers) from this review; however, these studies are common in the dengue literature. Additional research may be required regarding the suitability of vector presence or density alone, either entomologically or ecologically assessed, as a measure of dengue risk.

Dengue–poverty associations

Within this small sample of studies, roughly equal numbers of studies reported positive and null findings with respect to measures of income, education, structural housing condition, overcrowding, and socioeconomic status (Table 1). While nine of the 12 studies demonstrated some positive associations between measures of dengue and poverty, nine also presented null results and five negative results. Positive results highlighted the influence of low/intermediate socioeconomic status and household overcrowding, low-income areas, asset-based socioeconomic status, absence of air conditioning, low education, low income, poor housing quality, self-assessment of economic situation as poor, low family income, higher population density, and inappropriate use of covers on water containers. Null results included socioeconomic variables as predictors of dengue fever, spatial distribution of recent infections and mosquito density by income areas, income distribution and disease

occurrence, number of room air-conditioners, crowding, lack of access to regular indoor water supply, dengue distribution by deprived areas, education, access to water and sanitation, mean income, standard of living, knowledge and socioeconomic conditions, dengue knowledge and present of covers on jars and plastic buckets, socioeconomic conditions, and presence of cover of jars and plastic buckets. Of the five studies relating to access to water and sanitation (all of which measured this using the presence of a regular water supply as a proxy indicator), four reported null associations, while one reported a positive association.

Finally, negative associations between dengue and poverty included low level of schooling in low or intermediate socioeconomic areas which was associated with less infection, higher attack rates in highest-income areas, and those with higher education levels had higher rates of hospitalization from dengue. Of the 12 peer-reviewed articles referencing dengue–poverty relationships within the English-language literature, results point in various directions as to the strength or direction of this relationship. Taken together, the sample provides little in the way of conclusive evidence to support the assertion that dengue is a disease of poverty.

Discussion

Despite the relatively high volume of academic literature making some reference to relationships between dengue and poverty (260 unique articles found in this systematic review), few empirical studies have directly assessed the nature and strength of these associations. These findings provide weak support for previous narrative reviews of dengue by Gómez-Dantés and Willoquet¹² and Guha-Sapir and Schimmer,²⁹ and of climate and environmental health by Campbell-Lendrum and Corvalán,³⁰ which point to housing conditions in particular as important poverty-related dengue determinants. Although the strength of the association was not well established by this review, low income and poor physical housing conditions were somewhat more consistently correlated with dengue outcomes than were several other poverty indicators. Further investigations are needed to determine the nature and strength of these associations. In particular, detailed studies are needed that will further investigate which physical housing conditions are most relevant for dengue transmission. In addition, future research into dengue–poverty connections should be geared toward the use or development of standardized measures of both physical housing conditions and income.

Measures of poverty are particularly opaque and do not easily permit the comparison or replicability of research studies. These findings are surprising because of the current policy push linking the causes

of (and policy prescriptions for) dengue and other NTDs with environmental and social conditions of poverty — from poor housing and lack of access to water and sanitation to a lack of education and poor understanding of dengue transmission. If dengue–poverty connections become a priority for the research community — a goal of the NTD initiatives — future studies are required in order to elucidate which poverty indicators are most relevant to dengue transmission, and in which socio-environmental contexts. These future studies would benefit from the use of standardized measures of the indicators of poverty (to assist in comparability of studies) and from consideration of supra-household scales in measuring and reporting dengue–poverty connections.

The focus on narratives of poverty may instead mask primary determinants of the dengue’s spread, which has been supported by the evidence. That is, dengue thrives in tropical and subtropical climates that may disproportionately represent the world’s poor, yet control of the *Ae. aegypti* vector is not limited to poor people or poor areas. For example, though only five of the studies in our review included it, piped water has been suggested as one strategy to combat stagnant water, which serves as the breeding ground for the *Ae. aegypti*. On top of this, narratives focused squarely on the question of poverty fail to take into account the political–ecological factors driving the disease, especially rapid urbanization, international travel and climate change.^{3,4,17,18} There is a need for greater consideration of *Ae. aegypti* biology (and ecology more broadly) in future studies into the relationship between dengue and poverty.

Limitations

This review reveals an absence of English-language dengue–poverty research from China, India, and sub-Saharan Africa, where dengue prevalence is poorly documented but the disease is presumed endemic,³¹ and a dearth of literature exploring the impact of macro-economic factors on the relationship between poverty and dengue. A publication bias in favour of positive rather than null results may exist. Finally, this study focused only on the determinants of initial infection and did not consider factors such as health care. A more expansively scoped search of the research literature — to incorporate published research in other languages, non-indexed research, and research using social or ecological measures of dengue risk, may be warranted.

As such, the findings described in this review may have limited generalizability to other regions affected by dengue and publication bias may limit the conclusiveness. This review makes no comment on the intervening role of health care in the dengue–poverty relationship. Despite these research limitations, it is clear that there is a major research gap — particularly in the English-language, indexed and peer-

reviewed literature reaching global health decision makers and dengue policymakers — into direct relationship(s) between conditions of poverty and expressions of dengue fever.

Conclusions

There have been recent calls for the NTD research community to focus efforts on evidence-informed decision-making through systematic analysis of the research literature.³² Studies, such as ours, that point to a *lack* of evidence base to which policies, are being drawn from are important for critiquing current policies, identifying research gaps, and casting doubt on the benefits of interventions. There is clearly more work to be carried out by researchers in trying to flesh out the link between poverty and dengue fever.

Meanwhile, interventions targeted toward poor communities continue to predominate.² These interventions appear to have little basis in the research evidence. Furthermore, it remains possible that yet-unfounded discursive associations between dengue and poverty could actually cause well-meaning NTD initiatives to backfire. As Farmer³³ has pointed out, diseases that are understood to predominantly afflict the poor ‘are unlikely to garner funding for research and drug development — unless they begin to “emerge” into the consciousness and space of the nonpoor’. Policy and decision makers should exercise caution in asserting a relationship between dengue and poverty and should pay closer attention to more specific risk factors — including those faced by non-poor communities — in combating this rapidly spreading disease.

Disclaimer Statements

Contributors KM: Oversaw all aspects of design, measurement and evaluation; developed drafts of manuscript and approved final manuscript. JD: Contributed to manuscript drafts and oversaw submission of the manuscript. CJS: Data collection and analysis; contributed to manuscript preparation. SJE: Study design, guidance and supervision, result interpretation, manuscript correction, final approval of manuscript for publication.

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