

ORIGINAL ARTICLE

Mortality risks among blue- and white-collar workers: A time series study among Japanese men aged 25-64 years from 1980 to 2015

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Abstract

Objective: We aimed to analyse age-standardised mortality trends in Japan among blue- and white-collar male workers aged 25-64 years, by major causes of mortality from 1980 to 2015.

Methods: Five-yearly mortality data were extracted from occupation-specific vital statistics maintained by the Japanese Ministry of Health, Labour and Welfare. A time series study was conducted among employed men aged 25-64 years. Age-standardised mortality trends by occupational category were calculated separately for all cancers, ischaemic heart disease, cerebrovascular disease and suicide. Poisson regression analysis was performed to analyse mortality trends by occupational category for each cause.

Results: Mortality rates for all cancers and ischaemic heart disease were higher among white-collar workers than blue-collar workers throughout the 35-year study period. The gap in the mortality rates for all four causes of death among blue- and white-collar workers widened in 2000 after Japan's economic bubble burst in the late 1990s. Simultaneously, suicide mortality rates among white-collar workers increased sharply and have remained higher than among blue-collar workers.

Conclusions: White-collar male workers in Japan have a higher risk of mortality than male blue-collar workers. However, despite substantial differences, significant progress has been made in recent years in reducing mortality across all occupations in Japan.

KEYWORDS

blue-collar, Japan, mortality, occupation, white-collar

1 | INTRODUCTION

Inequalities in adult mortality have been widening globally over the years.¹ Cardiovascular disease and cancer accounted for one-fifth of the 56 million deaths that occurred

globally in 2017.² Occupation is often used as an indicator of socio-economic status.³ Various studies have reported an association between mortality and occupation across diverse countries and developmental settings.⁴ Moreover, there are marked differences in deaths by occupation, with factory

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workers facing higher mortality risks than professionals, such as teachers and doctors.⁵ Differences in the nature of individual occupations, and exposure to multiple risk factors across various occupations have been found to affect mortality.⁶

Cancer, cardiac disease, cerebrovascular disease and suicide are among the leading causes of death in Japan.⁷ With the decrease in the disease mortality, especially from ischaemic heart disease and cancer, Japan achieved the longest life expectancy in the world.⁸ However, in the 1990s, Japan experienced a financial crisis after its economic bubble burst. The number of bankruptcies in 1998 was the highest ever recorded for Japan and was paralleled by a surge in the age-standardised suicide rate during that year. In particular, rates of suicide mortality from hanging increased rapidly among middle-aged men.⁹ Differences in mortality trends were observed across diverse occupations, and mortality rates among managers worsened significantly over this period.¹⁰ Mortality trends among managers and professional workers are different, but it may be helpful to have a broader view of the mortality pattern among workers in two occupational groups—blue- and white-collar workers. A previous study compared nationwide mortality by occupation across Japan and European countries, but did not include men in the young workforce, and also did not use data from a long period before the financial crisis in the mid-1990s.¹¹ Unlike previous studies,^{10,11} this study analysed the trends among men over a longer period, 35 years, thus including the mortality trend for 15 years before and after the economic crisis in 1997. It also covered a broad age group, from 25 to 64 years because an increasing number of young people joining the workforce are exposed to higher risk of mortality at an early age. The year 2018 was 20 years since the economic crisis peaked in 1998. During this period, the economic situation has improved, with accelerated per capita output growth and increased productivity.¹² However, we believe that the highest socioeconomic group in Japan may still not be in the best possible health. We therefore aimed to analyse age-standardised mortality trends among blue- and white-collar male workers by cause of mortality from 1980 to 2015 in Japan.

2 | METHODS

Five-yearly cross-sectional mortality data were extracted from occupation-specific vital statistics maintained by the Japanese Ministry of Health, Labour and Welfare.¹³ Data on occupation-specific populations were obtained from the census records of the Statistics Bureau of Japan, which conducts a census every 5 years.¹⁴ We analysed mortality data obtained for men aged 25–64 years, categorised into 25–34, 35–44, 45–54 and 55–64-year age groups, separately by major mortality cause. Observations with missing values for occupation were removed from the analysis. In the years 1980 and 1985,

mining was used as a separate category and in the year 2010 and 2015 carrying/cleaning and construction were added as separate categories, which were not separately categorised in other years. These occupations were recategorised so that mining, construction and carrying/cleaning were categorised under manufacturing^{15,16} to ensure consistency for all of the years of the study (Table S1).

All workers were divided into white- or blue-collar occupational categories by merging categories using the Erikson-Goldthorpe-Portocarero scheme. Upper non-manual workers (professionals and managers) and lower non-manual workers (clerical, sales and service personnel) were categorised as white-collar workers, while manual workers (security, transportation, mining, carrying/cleaning, construction and manufacturing personnel) and agriculture workers were grouped as blue-collar workers.^{5,17} The unemployed category was not included in the analysis because it comprised individuals with diverse and non-comparable risk factors, including students who were not jobseekers and individuals who were retired or engaged in home duties. The unclassified and missing occupational categories were also excluded from the analysis.

2.1 | Statistical analysis

Age- and occupation-specific mortality rates for the period 1980–2015 were directly standardised by 5-year age groups using the 1985 population, which is generally used for standardisation for official Japanese statistics.¹⁸ Age-standardised mortality trends by occupational category were calculated for each of the four leading causes of death: cancer, ischaemic heart disease, cerebrovascular disease and suicide.

The ninth revision of the International Classification of Disease (ICD)-9 was used to code causes of death from 1980 to 1990, while the ICD-10 classification codes were used from 1995 onwards. Table S2 shows the codes for causes of death in both ICD versions.

We performed Poisson regression analysis to assess mortality trends by occupational category for each cause of death with year, age category and a step term as covariates. A step variable indicating whether the deaths occurred before or after 2000 was used to analyse mortality trends before and after the economic crisis that occurred in the late 1990s. To facilitate interpretation, the year 1980 was set as the baseline (0), so that the intercept in the model corresponded to mortality rates in 1980.

To analyse the mortality rates for cancer, ischaemic heart disease and cerebrovascular disease, we included a two-way interaction Poisson model of the year and occupation category (blue- and white-collar) with the age category and a step variable in separate analyses by cause of death. Accordingly, we analysed differences in mortality trends among white- and blue-collar workers. For the suicide mortality analysis, step and

occupation interactions were added to the model to assess the sharp increase in the suicide mortality level in 2000. Linear combinations of the key variables with 95% confidence intervals were calculated to capture changing mortality trends by occupational categories and to estimate the magnitude of changes in the mortality level that occurred in 2000. These linear combinations are shown as rate ratios in Table 3, which correspond to $\beta_1 + \beta_5$ in model 1 & 2, and in Table 4 as $\beta_4 + \beta_6$ in model 2. All of the analyses were performed using Stata IC version 15.1.

Data were modelled as a Poisson distribution, with the population, by occupation, included in the model as an offset. The model was developed as follows. For available data on the number of suicide deaths, y_i , occurring at rate μ_i in population n_i , the fundamental distribution of data was expressed as:

$$y_i \sim \text{Poisson}(\mu_i) \quad (1)$$

where rate μ_i is related to the covariates through a log-linear expression described below.

A two-way interaction model was constructed to assess the mortality trends for blue- and white-collar workers before and after 2000:

Model 1 (cancer, ischaemic heart disease, cerebrovascular disease)

$$\ln(\mu_i) = \alpha + \ln(n_i) + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \beta_4 x_{i4} + \beta_5 x_{i1} x_{i3}$$

Model 2 (suicide)

$$\ln(\mu_i) = \alpha + \ln(n_i) + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \beta_4 x_{i4} + \beta_5 x_{i1} x_{i3} + \beta_6 x_{i3} x_{i4}$$

where α is the intercept term; x_{i1} is the year, with the first year in the data series (1980) set at 0, and consecutive years at 5-year intervals; x_{i2} is the age category (1 = 25-34, 2 = 35-44, 3 = 45-54, 4 = 55-64 years old); x_{i3} is the occupational category (1 = blue-collar workers, 2 = white-collar workers); and x_{i4} is the step function (0 = years before 2000, 1 = 2000 onwards).

In the above model, categorical variables with more than two levels (ie, age groups) were constituted as sets of dummy variables. Thus, x_2 comprised a set of four dummy variables. However, for simplicity, these sets of dummy variables were expressed as a single term. We also conducted a similar analysis for men aged 25-34 (Tables S3 and S4).

3 | RESULTS

Table 1 shows changes in the proportions of occupation categories from 1980 to 2015. Full comprehension of the results of the analysis requires an understanding of the proportions of the population within the two occupation categories and how they have changed over time. The proportions of blue- and white-collar workers in 1980 were reversed over the 35-year

TABLE 1 Proportions of workers in the Japanese male population by occupation, 1980-2015

Year	Proportions of workers (%)	
	Blue-collar	White-collar
1980	53.7	46.3
1985	51.2	48.8
1990	49.1	50.9
1995	47.5	52.5
2000	47.1	52.9
2005	47.4	52.6
2010	44.7	55.3
2015	44.3	55.7

period of the study. Thus, in 2015, there was a slightly higher proportion of white-collar male workers aged 25-64 years than blue-collar workers within the Japanese workforce.

Figure 1 shows the age-standardised death rates per 100 000 population for blue- and white-collar workers attributed to various causes during the period 1980-2015. The all-cancer and ischaemic heart disease mortality rates were higher for white-collar workers than blue-collar workers during this period. Cerebrovascular disease and suicide mortality rates were higher among blue-collar workers in the 1980s but increased among white-collar workers from the mid- to late 1990s. From 1980 to 2015, the mortality rates decreased steadily for cancer, ischaemic heart disease and cerebrovascular disease and only very slightly for suicide. Figure S1 shows similar trends among men aged 25-34 years (Supplementary file).

Table 2 shows the age-standardised mortality rates and the absolute difference in rates between white- and blue-collar workers by cause of death and occupation from 1980 to 2015. The absolute difference between mortality rates from all four causes for white- and blue-collar workers widened to reach a maximum in 2000 following the economic crisis in the late 1990s. Differences in cancer mortality rates across occupational categories decreased significantly over the study period. In 2015, ischaemic heart disease, cerebrovascular disease and suicide mortality rates were almost equal for blue- and white-collar workers.

Table 3 shows estimated mortality trends for white- and blue-collar male workers calculated using linear combination of key variables in model 1. The rate ratio is the relative increase in mortality rate in the corresponding disease and occupational category for every increase in the 5-year interval. The table shows that 5-year mortality attributed to all four causes decreased at almost equal rates, by about 3% to 6%, among blue- and white-collar workers.

Table 4 shows changes in suicide mortality rates for white- and blue-collar workers in 2000 calculated using linear

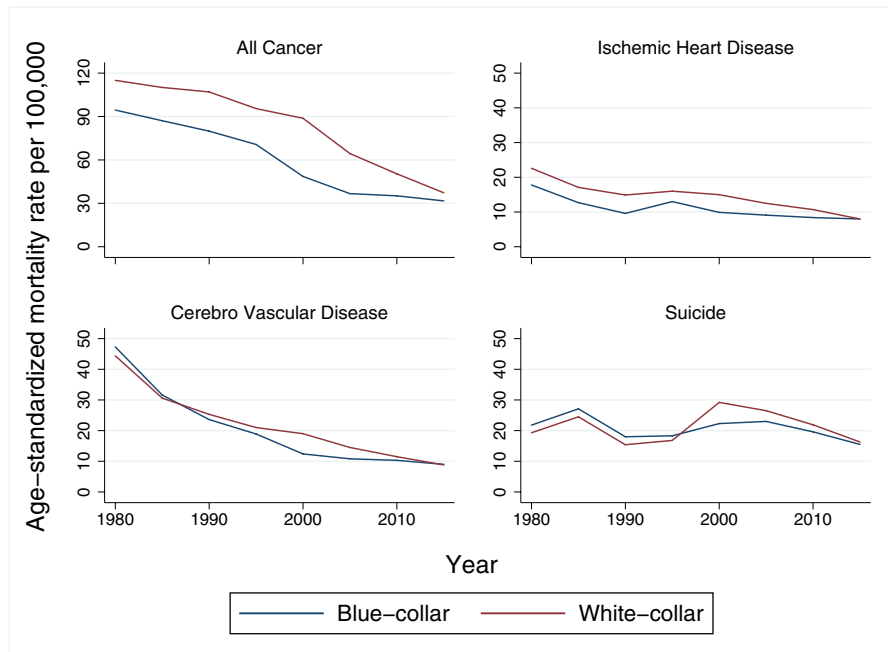


FIGURE 1 Age-standardised mortality rates per 100 000 population by cause of death among blue- and white-collar male workers in Japan

TABLE 2 Absolute differences in age-standardised mortality rates per 100,000 by cause of death and occupation among employed Japanese men aged 25–64 years from 1980 to 2015

Year	Cancer			Ischaemic heart disease			Cerebrovascular disease			Suicide		
	Blue	White	Difference ^a	Blue	White	Difference ^a	Blue	White	Difference ^a	Blue	White	Difference ^a
1980	94.5	115.0	20.5	17.8	22.6	4.8	47.3	44.4	-2.9	21.8	19.3	-2.5
1985	87.1	110.1	23	12.7	17.1	4.4	31.6	30.6	-1	27.1	24.5	-2.6
1990	79.9	107.0	27.1	9.6	14.9	5.3	23.6	25.3	1.7	18.0	15.4	-2.6
1995	70.7	95.5	24.8	13.0	16.0	3	18.9	21.0	2.1	18.3	16.8	-1.5
2000	48.6	88.8	40.2	9.9	15.0	5.1	12.4	19.0	6.6	22.3	29.2	6.9
2005	36.7	64.4	27.7	9.1	12.5	3.4	10.8	14.5	3.7	23.0	26.5	3.5
2010	35.2	50.4	15.2	8.4	10.7	2.3	10.3	11.5	1.2	19.6	21.9	2.3
2015	31.7	37.3	5.6	8.0	8.0	0	9.0	8.8	-0.2	15.5	16.3	0.8

^aAbsolute difference in age-standardised mortality rates between white- and blue-collar workers.

combinations of key variables in model 2. The rate ratio is the relative increase in suicide mortality rates in the corresponding occupational category after 2000 compared with before 1995. The suicide mortality rates increased for workers in both categories. However, the increase in mortality rates for blue-collar workers was relatively low compared with that for white-collar workers. Tables S3 and S4 show that there was a similar mortality trend and change in suicide level in 2000 among workers aged 25–34 years.

4 | DISCUSSION

Marked differences in mortality rates were evident across the two occupational categories over a period of 35 years.

Our results suggest that trends in mortality among both white- and blue-collar workers have been decreasing sharply since 2000. However, male white-collar workers in Japan are at higher risk of mortality than blue-collar workers. This finding contradicts those of studies that reported an increased risk in all-cause mortality⁵ and increased odds of poor self-rated health among blue-collar workers.¹⁹ A study among a cohort in Japan also found an increased risk of mortality among blue-collar workers than white-collar workers.⁵

Passive work, entailing low psychosocial job demands and low levels of job control, is associated with increased mortality, suggesting that job content influences workers' health.²⁰ White-collar workers are expected to adopt more diverse and autonomous approaches when performing their

TABLE 3 Mortality trends for male blue- and white-collar working population

Occupation	Rate ratio	Confidence interval
Cancer		
Blue	0.971	(0.970-0.972)
White	0.976	(0.975-0.977)
Ischaemic heart disease		
Blue	0.976	(0.974-0.978)
White	0.974	(0.972-0.976)
Cerebrovascular disease		
Blue	0.946	(0.944-0.948)
White	0.956	(0.954-0.957)
Suicide		
Blue	0.979	(0.976-0.981)
White	0.969	(0.967-0.972)

Note: Mortality trends are 5-yearly.

tasks compared with blue-collar workers, whose work tends to be uniform and standardised. Diverse work could plausibly lead to increased stress levels among workers. High levels of job strain over time have been found to be associated with a suppressed immune system, ultimately leading to a decline in health and an increase in the overall disease risk.²¹ White-collar productivity is lower than blue-collar productivity in Japanese companies, but job demands are higher among white-collar workers.²² In 2006, 28% of Japanese men in private companies worked over 12 hours a day, and in 2017, around 8% of both male and female workers worked more than 60 hours a week.²³ The enforcement of standardised measures to stop employees from working overtime, such as 'no overtime days', by Japanese companies proved ineffective because they prompted an increased amount of take-home work among white-collar workers.²⁴ Long working hours results in lack of physical activity, physical fatigue and psychological stress, which are associated with increased incidence of various diseases among white-collar men.²⁵ The findings of a study in Japan in 2015 suggest that approximately 65% of compensable cases of occupational cardiovascular disease involved overtime work amounting to 80-119 hours a month before disease onset.²⁶ These conditions partly explain the

TABLE 4 Changes in suicide mortality rates among male blue- and white-collar Japanese workers aged 25-64 years in 2000

Occupation	Rate ratio	Confidence interval	Per cent ^a
Blue	1.43	(1.36-1.51)	43.2
White	2.26	(2.15-2.37)	126.1

^aPer cent change in mortality rates.

higher mortality rates for white-collar workers compared with those for blue-collar workers.

Death from suicide, heart attack and stroke due to overwork is a growing concern among young workers in Japan. The mortality rate by suicide is very high compared with the other three causes among workers aged 25-34. The young workforce, who are replacing retiring older workers, are expected to work extra hours and take on additional workload. Recently, suicide linked to work-related stress, work overload and long working hours has increased among Japanese people aged 20-29.²⁷ Similarly, there is an increasing number of claimed and compensated cases for overwork-related cardiovascular and cerebrovascular diseases and mental health issues, especially among young employees.²⁸ Support for mental health issues for young workers needs to be promoted in the workplace.

Hypertension is more prevalent among white-collar workers compared to blue-collar workers,²² which could account for their higher rates of cerebrovascular disease and ischaemic heart disease. Job strain and lack of job autonomy are associated with an increased risk of cardiovascular mortality, especially among administrative workers.²⁹ A study in Taiwan showed a 5.3-fold increase in the risk of ischaemic heart disease among blue-collar workers relative to white-collar workers.³⁰ In Japan, blue-collar workers are more likely to report symptoms of cardiovascular disease, but white-collar workers are 1.6 times more likely to be diagnosed with cardiovascular disease.³¹ Maladaptive coping behaviours and physical inactivity mediate metabolic syndrome in white-collar workers.³² A study on Japanese male white-collar workers who worked long hours showed that key maladaptive lifestyle factors included reduced hours of sleep and a lack of physical activity.³³

In recent years, with insurance coverage of medications for ischaemic heart disease and cerebrovascular disease medications, the mortality for these diseases has decreased. Between 1970 and 2007, there was a significant reduction in mean systolic blood pressure in the Japanese population, which prompted a decline in proportion of stroke-related deaths in Japan by one-quarter to one-third of all-cause deaths.³⁴

A study in China found that blue-collar workers have a higher risk of all-cancer mortality compared with white-collar workers.³⁵ National cancer screening in Japan is associated with the prevention of stomach cancer. A hospital-based case-control study in Japan found a varying occupational gradient with occupational class and an excess risk of prostate cancer among professional workers in Japan.³⁶ Managers and professionals in Japan have a higher risk of renal cancer suggesting an association with high job stress.³⁷ Studies have proposed mechanisms for the adverse effects of psychological distress on cancer development. The workplace reform following the economic recession in the late 1990s put a lot of strain and

job demand on managers, increasing the risk of psychological distress,¹⁰ and potentially leading to an increased incidence of cancer among white-collar workers. Similarly, a study found that workers with high level of physical activity are likely to have a decreased risk of cancer.³⁸ Despite a lower smoking rate among white- compared to blue-collar workers,³⁹ our study's findings suggest an increased mortality risk for male white-collar workers in Japan. One reason for increased incidence of cancer could be the increased frequency of screening among individuals with high socio-economic status, resulting in overdiagnosis.⁴⁰

Mortality trends for ischaemic heart disease and suicide are decreasing faster among white-collar workers compared with blue-collar workers. This difference could be attributed to several advantages that white-collar workers have over blue-collar workers, such as better incomes and working conditions, time flexibility and supportive social ties. A high socio-economic position is inversely associated with disease mortality and morbidity.⁴¹ Similarly, the association between socio-economic status and health is influenced by the level of economic development.⁴² After the economic bubble burst in the late 1990s, the gap in the mortality rates of blue- and white-collar workers initially widened but subsequently decreased in the following years. Structural employment reforms and the diffusion of information and communication technology in the late 1990s positively influenced the work environment of white-collar workers,⁴³ promoting efficient job execution.⁴⁴ It is therefore likely that stress and consequently mortality were reduced.

In 2000, suicide levels increased among both white-collar and blue-collar workers in Japan. The increase in suicide rates for blue-collar workers, however, was relatively low compared with that for white-collar workers. The suicide rate of white-collar workers increased sharply in 2000, and the mortality rate has subsequently remained higher than blue-collar workers. The sharp increase in suicide mortality among white-collar workers in 2000 is likely to have been caused by the economic reforms that were introduced after the economic bubble, and not solely the work environment. Deteriorating health is linked to essential determinants, such as economic conditions. The sharp rise in suicide rates in 2000 among both white- and blue-collar workers could be because the proportion of the reduction of the Japanese workforce following the economic crisis in 1998 increased from 1.3% in 1995 to over 3.8% in 2000 and the following years, with 27.5% of companies implementing labour adjustments in 2002.⁴⁵

The findings from this study show that the financial crises in the mid-1990s had a bigger impact on white-collar than blue-collar workers. The labour reforms reduced the proportion of managers in the workforce from 6.3% in 1995 to 3.2% in 2005, potentially increasing their job responsibilities and job demands compared with blue-collar workers.¹⁰ During the economic recession in the late 1990s, the average working

hours of regular workers increased in Japan, while their proportion decreased in the workforce.⁴⁶ In addition, unpaid overtime hours increased in the late 1990s, especially among white-collar workers, because of the cutbacks in funds during the economic crisis. Managers were at high risk of overtime work without pay due to the “white-collar exemption.” This factor could have induced rising stress levels among white-collar workers, leading to compromised health outcomes and suicide. In South Korea, the main groups affected by job losses in 1998 were workers from the lowest echelons, such as clerical workers.⁴⁷ Following the formulation and implementation of suicide prevention policies in Japan in the mid-2000s, suicide rates among both blue and white-collar workers began to decline. The amendment of the Basic Act on Suicide Prevention in 2016, requiring municipalities to formulate suicide prevention plans, may have also prompted the steady decline in Japanese suicide rates in recent years.

Our study has a few limitations. There may be information bias potentially leading to misclassification of occupation into specific categories because data on the last occupation of the deceased were obtained from family and were not based on records. We excluded unclassified occupational categories, which mostly consisted of economically inactive men with unknown last occupation,¹⁶ without adjusting for the mortality differences. Men in lower occupational classes are more likely to be economically inactive and also have a different risk of mortality from those in higher occupational classes, so this could have led to bias. However, they only represented a small proportion of the total workforce. Similarly, changes in variable codes and occupational categories during the study period may also have affected the results. Analysing the data with detailed information on employment conditions would have been very informative, but was not possible in this study due to unavailability of data on these variables. This study focused on mortality among men only, and further studies are needed to investigate if the patterns of mortality observed among men also apply to the female population. This study standardised mortality rates using the 1985 population as standard, which is consistent with most Japanese studies. However, with the super-ageing Japanese population, the age distribution varies significantly from 1980 to 2015. Thus, the 1985 population with a relatively higher proportion of young people tend to weight event at these ages disproportionately.⁴⁸ The periodic revisions of the International Classification of Disease may also have had some effect on the cause of death and other variables in this study. Studies have shown that revision is likely to create discontinuity in mortality statistics.⁴⁹ This study used data from both ICD-9 and ICD-10, which may have had some impact on the computed mortality rates, thus ICD classification comparability ratios might need to be taken into account when interpreting the mortality statistics.

In conclusion, white-collar male workers in Japan have a higher risk of mortality compared to male blue-collar

workers. However, despite substantial differences, significant progress has been made in recent years in reducing mortality across all occupations in Japan.

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DISCLOSURE

Approval of research protocol: Formal ethical approval was not required as we obtained de-identified data for research purposes. *Informed consent*: N/A. *Registry and the registration no. of the study/trial*: N/A. *Animal studies*: N/A. The authors declare no Conflict of Interests for this article.

AUTHOR CONTRIBUTIONS

BD, TM, KW and SG conceived the ideas; KW received the data; BD, TM and SG analysed the data; BD and TM led the writing; and KW and SG revised the manuscript. All authors have read and approved the manuscript.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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