Original Contribution

Using Annual Data to Estimate the Public Health Impact of Extreme Temperatures

William B. Goggins*, Chunyuh Yang, Tomiko Hokama, Lewis S. K. Law, and Emily Y. Y. Chan

* Correspondence to Dr. William B. Goggins, Jockey Club School of Public Health and Primary Care, The Chinese University of Hong Kong, Shatin, Hong Kong SAR, People’s Republic of China (e-mail: wgoggins@cuhk.edu.hk).

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Short-term associations between both hot and cold ambient temperatures and higher mortality have been found worldwide. Few studies have examined these associations on longer time scales. Age-standardized mortality rates (ASMRs) were calculated for 1976–2012 for Hong Kong SAR, People’s Republic of China, defining “annual” time periods in 2 ways: from May through April of the following year and from November through October. Annual frequency and severity of extreme temperatures were summarized by using a degree-days approach with extreme heat expressed as annual degree-days >29.3°C and cold as annual degree-days <27.5°C. For example, a day with a mean temperature of 25.0°C contributes 2.5 cold degree-days to the annual total. Generalized additive models were used to estimate the association between annual hot and cold degree-days and the ASMR, with adjustment for long-term trends. Increases of 10 hot or 200 cold degree-days in an annual period, the approximate interquartile ranges for these variables, were significantly (all $P’s \leq 0.011$) associated with 1.9% or 3.1% increases, respectively, in the annual ASMR for the May–April analyses and with 2.2% or 2.8% increases, respectively, in the November–October analyses. Associations were stronger for noncancer and elderly mortality. Mortality increases associated with extreme temperature are not simply due to short-term forward displacement of deaths that would have occurred anyway within a few weeks.

ambient temperature; biometeorology; climate change; mortality; time series

Abbreviations: ASMR, age-standardized mortality rate; SAR, Special Administrative Region.

The reality of climate change has led to increased interest in the health impacts of meteorological conditions (1). One important research goal is estimating the public health impact of extreme temperatures.

Most studies examining associations between meteorological variables and mortality/morbidity have been done by using daily time series (2–8). A common approach is to use Poisson generalized linear (or additive) models with daily deaths or hospitalizations as the outcome and temperature, generally same day and lagged temperatures, as the predictor variable of interest, while controlling for potential confounders, including daily pollutant levels, season, and long-term trend (2–7). Some studies include other meteorological variables or composite functions of meteorological variables, like apparent temperature (4). Many studies have examined excess mortality associated with specific extreme events, such as the 2003 European heat wave (9).

A short-term association between temperature and mortality/morbidity has been well established from these studies, with mortality generally higher following both cold and hot days relative to days with moderate temperatures (2–8). The hot and cold “thresholds” at which excess mortality begins to appear, however, vary between locations, with warmer overall climates generally having higher thresholds than cities with cooler climates (2, 3).

Any assessments of the public health impact of short-term meteorological conditions would need to account for short-term forward mortality displacement, also referred to as “harvesting,” the bringing forward in time of deaths that would have occurred within a short period anyway. It has been argued by some that the public health significance of time-series associations between mortality and environmental variables could be small if excess deaths, in fact, were occurring in those who would have died within a few days in the absence of the exposure (10).
In this paper, we examine the association between the yearly distributions of mean daily ambient temperature and annual age-standardized mortality rates using data from Hong Kong Special Administrative Region (SAR), People’s Republic of China. Modeling data on an annual time frame negates the influence of short-term forward mortality displacement and allows an assessment of the public health impact of meteorological conditions.

**METHODS**

**Data**

Data on all deaths, including date of death, cause of death, and age and sex of the decedent, and total mid-year population by sex and 5-year age group (0–4, 5–9, . . . , 80–84, ≥85) for Hong Kong for 1976–2012 were obtained from the Hong Kong Census and Statistics Department. Daily mean temperature data for the same years were obtained from the Hong Kong Observatory, while pollutant levels for 1986–2012 were obtained from the Hong Kong Environmental Protection Department, and influenza consultation rates were obtained from the Hong Kong Department of Health.

**Calendar periods used for the analyses**

Two separate calendar year periods were used in the analyses. One defined “years” as 365(6)-day periods from May 1 to April 30 of the following year. For example, year 1 was defined as the period from May 1, 1976, to April 30, 1977, and year 36 as the period from May 1, 2011, to April 30, 2012. Defining annual periods in this way meant that nearly all of the hot weather days occurred in the first 5 months of the period; thus, any deaths forward displaced by less than 7 months due to hot weather would not affect the overall mortality for the period. The second analysis defined years as the 365(6)-day period from November 1 to October 31 of the following year. Defining annual periods in this way meant that most of the cold weather days occurred in the first 5 months, and most deaths forward displaced by less than 7 months due to cold weather would not affect the overall mortality.

**Statistical methods**

Age-standardized mortality rates (ASMRs) were calculated by using direct standardization and the new World Standard Population (11). The sex- and age-specific populations for each time period used in the calculations were the weighted average of the relevant mid-year populations. For example, the population for the May 1976–April 1977 period was calculated as $(8/12) \times (1976$ mid-year population$) + (4/12) \times (1977$ mid-year population$)$, while that for the November 1976–October 1977 period was calculated as $(2/12) \times (1976$ mid-year population$) + (10/12) \times (1977$ mid-year population$)$. The severity of hot and cold temperature exposures during a given period was summarized by using a degree-day approach. Annual cold degree-days (DDCOLD) were defined as the sum over the year of daily values of $DD_{COLD} = Temp$ where $Thresh_{COLD}$ is the threshold below which cold impacts on mortality are believed to begin, and Temp is the mean daily temperature. Thus, for example, if the threshold is 24.0°C, a day with Temp $\geq 24.0°C$ would contribute cold degree-days $= 0$, and days with Temp $= 22.0°C$ and 20.3°C would contribute 2 and 3.7 degree-days, respectively. Annual hot degree-days were defined similarly as $DD_{HOT} = Temp − Thresh_{HOT}$. The thresholds were chosen by a grid search as those that minimized the generalized cross-validation score of the model. Initial possible values for the cold thresholds were from 20°C to 28°C and for hot degree-days from 28°C to 31°C. The initial search used 0.5°C increments, followed by 0.1°C increments after the range was narrowed down. The search ranges were based on the observed short-term associations between daily mortality and mean temperatures.

The degree-day variables were then included as predictors in generalized additive models with the natural logarithm (LN) of annual ASMR as the outcome and a smooth term for year of study controlled as a confounder, with degrees of freedom chosen by the mgcv program (12) in R, version 2.10.0, statistical software (R Foundation for Statistical Computing, Vienna, Austria). Possible overdispersion was accounted for by using the quasi-Poisson link in mgcv. The model formula is as follows:

$$\text{LN(ASMR)} = \beta_0 + \beta_{DD_{HOT}} \times DD_{HOT} + \beta_{DD_{COLD}} \times DD_{COLD} + s(\text{year of study}, \text{ maxdf} = 5) + \epsilon,$$

where maxdf is the maximum permitted degrees of freedom by the mgcv program for the trend term. Estimated percentage changes in ASMR associated with particular changes in hot or cold degree-days, $\Delta DD_{HOT}$ or $\Delta DD_{COLD}$, were calculated.
from the relative risks from the generalized additive models as:

Percentage change

\[ \frac{\text{relative risk}}{C_0} \times 100 \]

where relative risk

\[ \exp(\beta_H \times \Delta DD_{HOT(COLD)}) \].

To facilitate comparisons between models, we estimated changes in mortality from the models for increases of 10 in hot degree-days and increases of 200 in cold degree-days for both sets of analyses. Note that these changes are close to the interquartile ranges for these variables (Table 1).

Model checking and sensitivity analyses

Although pollutant concentrations were not available for all years in the series, annual mean concentrations of nitrogen dioxide, particulate matter ≤10 μm, and ozone were included in sensitivity analyses using the subset of the data, 1986–2012, for which these variables were available. Influenza consultation rates were available only for the years 1998–2012, and sensitivity analyses were also done including influenza in the models using the data for these years only. Model residual versus fitted plots were examined, and partial autocorrelations for the residuals were also checked. Partial regression plots for the outcome and predictors were examined to evaluate the possible influence of outliers. We also tried varying the maximum degrees of freedom for the trend, trying integer values from 3 to 7, to see if this changed the parameter estimates for the degree-day variables substantially.

Our modeling approach makes a specific assumption about the association between the annual daily mean temperature distribution and the ASMR. For example, since the threshold for hot degree-days is 29.3°C, a single day with a mean temperature of 32.3°C would contribute the same number of hot degree-days, 3, as 3 days with a mean temperature of 30.3°C and, thus, would be assumed to have an equal influence on the ASMR (refer to Web Table 1, available at http://aje.oxfordjournals.org/). To test this assumption, we performed a sensitivity analysis by adding additional hot and cold degree-day terms to the existing model. Additional cold degree-day terms for temperatures below 21.5°C (18.5°C,

Table 2. Estimated Percentage Increases in Annual Age-Standardized Mortality Rates Corresponding to Changes in Annual Frequencies of Hot and Cold Degree-Days, Hong Kong SAR, People’s Republic of China, May 1, 1976–April 30, 2012

<table>
<thead>
<tr>
<th>Type of Mortality</th>
<th>Increase of 10 in Annual No. of Hot Degree-Days &gt;29.3°C</th>
<th>Increase of 200 in Annual No. of Cold Degree-Days &lt;27.5°C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated Increase in ASMR, %</td>
<td>95% CI</td>
</tr>
<tr>
<td>All natural deaths</td>
<td>1.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.5, 3.4</td>
</tr>
<tr>
<td>By age of death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;75 years</td>
<td>1.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.1, 2.7</td>
</tr>
<tr>
<td>≥75 years</td>
<td>2.4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.6, 4.3</td>
</tr>
<tr>
<td>By date of death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 1976–April 1994</td>
<td>2.0</td>
<td>−0.6, 4.7</td>
</tr>
<tr>
<td>May 1994–April 2012</td>
<td>1.3&lt;sup&gt;d&lt;/sup&gt;</td>
<td>−0.1, 2.6</td>
</tr>
<tr>
<td>By cause of death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>1.0&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.1, 1.8</td>
</tr>
<tr>
<td>Noncancer</td>
<td>2.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.1, 4.8</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>2.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.1, 4.5</td>
</tr>
<tr>
<td>Respiratory</td>
<td>1.3</td>
<td>−2.1, 4.7</td>
</tr>
</tbody>
</table>

Abbreviations: ASMR, age-standardized mortality rate; CI, confidence interval.

<sup>a</sup> P < 0.02.

<sup>b</sup> P < 0.01.

<sup>c</sup> P < 0.05.

<sup>d</sup> P < 0.10.
15.5°C, and 12.5°C) and a hot degree-day term above 30.3°C were tried individually in the models. These degree-day terms were created in the same way as the DD\textsubscript{COLD} and DD\textsubscript{HOT} terms that were used in the main models. Additional details on the methods used in the sensitivity analyses are presented in Web Appendix 1.

Figure 2. Partial regression plot of the age-standardized mortality rate (ASMR) versus annual hot degree-days (A) and annual cold degree-days (B), Hong Kong SAR, People’s Republic of China, May 1976–April 2012. The year listed on the plot is the year of the beginning of the period (i.e., 1976 refers to May 1976–April 1977).
RESULTS

Descriptive statistics

Descriptive statistics for the study variables are shown in Table 1. The trend in ASMRs over the years of the study is shown in Figure 1. For the May–April analysis, the hot and cold degree-day thresholds that minimized the generalized cross-validation score were 29.5°C and 27.6°C, respectively. These values also yielded the lowest P values in tests of significance for the coefficients. For the November–October analysis, these values were 29.2°C and 27.4°C. In order to facilitate comparisons between models, we adopted compromise common thresholds for both models of 29.3°C and 27.5°C. About 18% of days had mean daily temperatures between 27.5°C and 29.3°C and, thus, did not contribute to either degree-day term. Although there was a moderate negative correlation between annual cold degree-days and annual hot degree-days for both May–April ($r = -0.38$, $P = 0.023$) and November–October ($r = -0.35$, $P = 0.037$), these correlations were considerably attenuated after controlling for annual trend (May–April partial $r = -0.20$, $P = 0.25$; November–October partial $r = -0.16$, $P = 0.36$).

Generalized additive model results

May–April analyses. An increase of 10 hot degree-days was associated with a 1.9% (95% confidence interval: 0.5, 3.4; $P = 0.011$) increase in the ASMR, while an increase of 200 cold degree-days was associated with a 3.1% (95% confidence interval: 1.3, 5.0; $P = 0.0017$) increase in the ASMR (Table 2). Partial regression plots, which show the nature of associations between the logarithm of ASMR and hot degree-days, adjusting for trend and cold degree-days, and between the logarithm of ASMR and cold degree-days, adjusting for trend and hot degree-days, are shown in Figure 2A and 2B, respectively. Residuals were not associated with predicted values, and partial autocorrelation plots showed only weak nonsignificant autocorrelations of the residuals. Results stratified by age at death, period of death, and cause of death are shown in Table 2. Associations were positive in all subgroup analyses except for cold degree-days and cancer mortality. The associations between ASMRs and both hot and cold degree-days were stronger for those older than 75 years of age and considerably stronger for noncancer ASMRs. There was not much difference in the strength of association between the earlier period, May 1976–April 1994, and the latter period, May 1994–April 2012, for cold degree-days, while the association for hot degree-days was weaker in the latter period.

November–October analyses. An increase of 10 hot degree-days was associated with a 2.2% (95% confidence interval: 1.0, 3.3; $P = 0.00092$) increase in the ASMR, while an increase of 200 cold degree-days was associated with a 2.8% (95% confidence interval: 1.0, 4.5; $P = 0.0025$) increase in the ASMR (Table 3). Partial regression plots showing the associations between logarithm of ASMR and hot degree-days and between ASMR and cold degree-days, adjusting for trend and hot degree-days, are shown in Figure 3A and 3B, respectively. Residuals were not associated with predicted values, and partial autocorrelation plots showed only weak and nonsignificant autocorrelation in the residuals. Results stratified by age at death, period of death, and cause of death are shown in Table 3. Associations were positive in all subgroup analyses except for cold degree-days and cancer mortality. The associations between ASMRs and both hot and cold degree-days were stronger for those older than 75 years of age and for noncancer mortality. The associations for cold degree-days were similar for the early and latter periods, while associations for hot degree-days were weaker for the latter period.

Table 3. Estimated Percentage Increases in Annual Age- Standardized Mortality Rates Corresponding to Changes in Annual Frequencies of Hot and Cold Degree-Days, Hong Kong SAR, People’s Republic of China, November 1, 1976–October 31, 2012

<table>
<thead>
<tr>
<th>Type of Mortality</th>
<th>Increase of 10 in Annual No. of Hot Degree-Days $&gt;$29.3°C</th>
<th>Increase of 200 in Annual No. of Cold Degree-Days $&lt;$27.5°C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated Increase in ASMR, % 95% CI</td>
<td>Estimated Increase in ASMR, % 95% CI</td>
</tr>
<tr>
<td>All natural deaths</td>
<td>2.2abc</td>
<td>2.8abc</td>
</tr>
<tr>
<td>By age of death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;75 years</td>
<td>1.4bc</td>
<td>1.9c</td>
</tr>
<tr>
<td>≥75 years</td>
<td>2.8a</td>
<td>3.6a</td>
</tr>
<tr>
<td>By date of death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>November 1, 1976–October 31, 1994</td>
<td>2.9b</td>
<td>2.6d</td>
</tr>
<tr>
<td>November 1, 1994–October 31, 2012</td>
<td>1.0</td>
<td>2.3a</td>
</tr>
<tr>
<td>By cause of death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>0.9c</td>
<td>0.0</td>
</tr>
<tr>
<td>Noncancer</td>
<td>2.8b</td>
<td>4.0b</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>2.9b</td>
<td>3.7c</td>
</tr>
<tr>
<td>Respiratory</td>
<td>2.7b</td>
<td>6.3b</td>
</tr>
</tbody>
</table>

Abbreviations: ASMR, age-standardized mortality rate; CI, confidence interval.

a $P < 0.001$.
b $P < 0.01$.
c $P < 0.02$.
d $P < 0.05$.
e $P < 0.10$.
significant (Web Tables 4 and 5). Including influenza consultation rates in models for the 1998–2012 data also did not substantially change the parameter estimates for hot or cold associations (Web Tables 4 and 5). Parameter estimates were also not changed much when the maximum degrees of freedom for the trend term were varied (Web Tables 4 and 5).
DISCUSSION

The results of our study indicate that annual time periods with a greater frequency and severity of both hot and cold weather tend to have higher mortality rates than years with more moderate daily temperature distributions in Hong Kong. This result is consistent with studies that have used daily time-series data to examine temperature-mortality associations (2–8). If the temperature-mortality associations observed on daily time scales were due to short-term or even medium-term (several months) forward mortality displacement, we would not expect to observe this association on an annual time scale. In Hong Kong, nearly all (99%) of the hot degree-days >29.3°C occurred from May to September, while most of the cold degree-days (83%) occurred from November to March (92% from November to April). Therefore, in the May–April models, most forward mortality displacement of less than 7 months due to hot weather would have been compensated with decreased mortality during the same period and would not affect the ASMR. Likewise, in the November–October models, most forward displacement of less than 7 months due to cold weather would also have not affected the ASMR. We can therefore regard the hot degree-day parameter estimates from the May–April models and the cold degree-day parameter estimates from the November–October models as being more harvesting resistant. The hot degree-day parameter estimates from the November–October models and the cold degree-day estimates from the May–April models will be resistant to only short-term displacement, as most of the relevant extreme weather would have occurred closer to the end of the time period. Therefore, it is not surprising that the hot estimates for the May–April models and the cold estimates for the November–October models are slightly lower. Nonetheless, the more harvesting-resistant estimates are still highly significant, and this suggests that exposure to hot and cold weather that is within the “normal” range for Hong Kong led to deaths in people that would have lived substantially longer in the absence of the exposure.

The issue of forward mortality displacement is complex. Deaths from any cause are always forward displaced in a sense as everyone eventually dies, and the distinction as to whether a death is considered to represent “harvesting” or not is a matter of the degree of forward displacement. Most studies examining forward mortality displacement have looked at heat waves and/or cold spells and evaluated evidence of displacement over periods from a few days to a few weeks after the extreme temperatures have ended (8, 9, 13–16). A study of mortality in several French cities during and after the 2003 European heat wave (9) estimated that only about 8% of the >3,000 excess deaths attributed to the heat wave were due to displacement of 3 weeks or less. A Czech study of several heat waves from 1982 to 2000 examined mortality displacement and concluded that forward displaced deaths made up a substantial proportion of excess mortality for some heat waves but not for others (13). Similarly, a Dutch study, which considered displacement up to 30 days after heat or cold waves, found inconsistent evidence of displacement following heat waves and no evidence of displacement following cold waves (15). A study using data from 7 US cities, which considered forward displacement out to 15 days, found that the extent of displacement depended on how extreme the heat event was, with a smaller percentage of excess deaths attributed to displacement for more extreme events (16). However, even for the most severe heat events, they estimated that about 50% of excess mortality was due to displacement (16).

In addition to depending on the severity of the weather event, the extent of forward mortality displacement is likely to depend on the characteristics of the individual population being considered. A comparison of mortality displacement of heat-related deaths among Delhi, India, Sao Paulo, Brazil, and London, United Kingdom (14), which considered periods up to 28 days, found evidence of high displacement for London and little displacement for Delhi, while the results for Sao Paulo were intermediate. The authors attribute this to the fact that in London most deaths occur among elderly people already suffering from chronic diseases, whereas Delhi has a relatively poor population with a high proportion of deaths among children and caused by infectious diseases (14). As this study looked at displacement following general heat exposure rather than following heat waves, the degree of displacement is expected to be less. Studies looking at potential displacement over longer periods are less common. A study using data from Sweden found that the summertime association between heat and mortality for a given year was weaker when the cardiorespiratory mortality rates were higher the previous winter, thus indicating forward mortality displacement of a few months (17). The authors describe this finding as likely due to a smaller pool of fragile individuals after a period of high winter mortality (17).

Our findings that both hot and cold weather associations were stronger for deaths among those over 75 years of age and for deaths due to causes other than cancer are consistent with findings from daily time-series studies from Hong Kong (5, 18) and elsewhere. The fact that the model for more recent years shows a weaker association of hot weather with mortality is not unexpected as economic development in Hong Kong has likely allowed greater adaptation to hot weather (e.g., greater ownership and use of air conditioning). Although hotter weather in Hong Kong could lead to further adaptation, the extent of potential adaptation may be limited. Prior studies have shown that the threshold at which heat and cold impacts on mortality begin to be observed depends heavily on the climate of the location being studied (2, 3, 6, 7, 9). This has been taken as evidence of adaptation, both physiological and environmental (i.e., use of air conditioning and/or central heating) by the local population. However, a study from the United States (16) found evidence that the association between average summer temperatures and threshold temperatures for heat impacts weakens at higher levels for average temperatures. The authors propose that this may be evidence of a “thermal physiological limit” and that a population’s susceptibility would depend on both relative and absolute temperatures (16). In addition, the ability of Hong Kong’s population to further adapt may be limited by economic factors. Although Hong Kong has a high per-capita income, it also has the highest income inequality of any developed country (5), and a considerable proportion of the population still lives in poverty. Thus, inability to afford air conditioning and heating or reluctance to pay for the necessary electricity may leave a proportion of the population particularly vulnerable to temperature extremes. Direct comparison of the magnitude and thresholds for the heat and cold impacts.
from the annual data with those obtained from daily time-series studies is complicated by the difference in outcomes, ASMR versus daily death count, and the fact that we do not have daily mortality data for Hong Kong for the earlier period. However, a rough comparison with our result for more recent years suggests that, although our threshold for heat impacts of 29.3°C was slightly higher than what we find with short-term data, the magnitude of the heat and cold impacts on ASMR is roughly similar to what would be predicted from the short-term models. The slightly higher heat threshold may indicate that some harvesting exists for deaths from high temperatures just above the short-term threshold.

Our study does have some limitations. Daily mean air temperature was measured at a single fixed monitoring site in central Hong Kong and may not exactly reflect the actual temperature to which residents were exposed. The only confounder we were able to control for the entire series was time trend. We feel that the trend variable captures the effects of improvements in medical care over time and cohort effects, such as improved nutrition and lower smoking rates, which cause ASMRs to decline over time. However, other confounders, such as pollutant levels and influenza epidemics, could also have biased the results. Sensitivity analyses indicated that the inclusion of annual mean pollutant levels for parts of the series for which they were available did not have much impact on the parameter estimates for hot and cold degree-days. A further limitation is our sample size of 36 years, which limits the precision of our estimates.

In conclusion, our most important finding was that the annual frequency of both hot and cold temperatures appears to have influenced annual mortality rates in Hong Kong over the last 4 decades. This result implies that the excess mortality observed during periods of hot or cold weather is not simply due to short- or medium-term forward mortality displacement, and that a substantial proportion of these deaths occurred in people who would have been expected to live at least several more months in the absence of these exposures. Further research looking at long-term associations between mortality and temperature in different locations is necessary to both validate our result and to explore this association in areas with different climates and levels of development.

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Author affiliations: Division of Biostatistics, The Jockey Club School of Public Health and Primary Care, The Chinese University of Hong Kong, Shatin, Hong Kong SAR, People’s Republic of China (William B. Goggins, Lewis S. K. Law); Department of Public Health, Kaohsiung Medical University, Kaohsiung, Taiwan (Chunyuh Yang); Graduate School of Health Science, University of the Ryukyus, Okinawa, Japan (Tomiko Hokama); and Division of Family Medicine, The Jockey Club School of Public Health and Primary Care, The Chinese University of Hong Kong, Shatin, Hong Kong SAR, People’s Republic of China (Emily Y. Y. Chan).

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REFERENCES