Article

Weather and Age-Gender Effects on the Projection of Future Emergency Ambulance Demand in Hong Kong

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Abstract

An accurate projection for ambulance demand is essential to enable better resource planning for the future that strives to either maintain current levels of services or reconsider future standards and expectations. More than 2 million cases of emergency room attendance in 2008 were obtained from the Hong Kong Hospital Authority to project the demand for its ambulance services in 2036. The projection of ambulance demand in 2036 was computed in consideration of changes in the age-gender structure between 2008 and 2036. The quadratic relation between average daily temperature and daily ambulance demand in 2036 was further explored by including and excluding age-gender demographic changes. Without accounting for changes in the age-gender structure, the 2036 ambulance demand for age groups of 65 and above were consistently underestimated (by 38%-65%), whereas those of younger age groups were overestimated (by 6%-37%). Moreover, changes in the 2008 to 2036 age-gender structure also shift upward and emphasize relationships between average daily temperature and daily ambulance demand at both ends of the quadratic U-shaped curve. Our study reveals a potential societal implication of ageing population on the demand for ambulance services.

Keywords

ambulance demand, forecasting, Hong Kong, statistical regression, weather effects

Introduction

Ageing population is a global issue that has been widely discussed in multidisciplinary research. It has also been reported that demographic ageing, or an increase in the percentage of elderly people aged 65 and above, is the current trend in most countries.[1] The United Nations projected that the 2035 proportion of elderly people in Europe would be 24.1%, representing a 7.8 percentage point increase in comparison to that in 2010. The same situation was expected in Asia, which would report a 6.5 percentage point increase from 6.7% to 13.2%.[2] Population ageing is a serious social concern because the older population is the likely contributor to the growing

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demand for health services and emergency ambulance attendance. It was estimated that within the period from 1996 to 2001, 25% of growth in ambulance numbers could be attributed to ageing and population growth, according to a study in Australia.[3]

Physical vulnerability in later life is a major contributor to the frequent use of health services. Older people tend to have the greatest health needs given the growing prevalence of chronic medical conditions and a higher incidence of age-related acute illnesses.[4] Compared with other age groups, older adults not only use emergency departments more, but they are also subject to higher risks of medical complications. The burden of diseases and repeat visits of older adults to the emergency departments are signals of an ongoing process of decline in physical health conditions rather than just isolated health incidents. Studies have also indicated that many of the emergency episodes involving elderly people do require immediate medical attention, but a substantial proportion of non-life-threatening events could likely be attended in a less-resource-intensive clinical setting.[5]

The harmful health effects of temperature on elderly people, during both hot and cold days, have been widely reported.[6,7] Locally in Hong Kong, Yan found a strong and significant relationship between weather and mortality in the 65 years and older age group (adjusted $R^2 = 0.49$) but not for the 0 to 24 and 25 to 44 age groups, by using monthly data from 1980 to 1994.[8] Excess mortality has been attributed to extreme temperatures culminating in obstructive cardiovascular and respiratory conditions. Under extreme weather, abrupt changes in the body temperature increase the symptoms of chronic pulmonary disease, resulting in greater use of medical services, including ambulance transfers, emergency visits, or hospitalization.[9,10] For example, another local study showed that common weather factors had a significant relationship with daily ambulance demand from 2006 to 2009.[11] In particular, a strong relationship between daily ambulance demand and average temperature persisted only among people aged 65 years and older (adjusted $R^2 = 0.71$) but not for the remaining age groups.

Kan et al[12] found a J- or U-shaped relationship between temperature and daily mortality from 2001 to 2004 among Shanghai residents, in which the mortality risk decreased from the lowest temperature to an inflection point and then increased with higher temperatures. The study mentioned before by Wong and Lai also established a U-shaped relationship between average temperature and the daily ambulance demand that amplified observed increases in emergency services for colder and hotter temperatures.[11] Along with an ageing population, these research findings signal possible worsening of future situations under climate change and a higher frequency of extreme summer temperatures. There is little work on possible societal and health impacts from thermal extremes, which heightens the need for better characterization of climate-health relationships to identify vulnerable groups and potential modifiers of the health impact.

The relationship between ambulance demand and weather factors has been established using recent data[11,13] and mostly for a 1-year projection.[14,15] A short-term projection of about 5 to 10 years ahead had been attempted,[16,17] but a longer lead time is needed for Hong Kong in strategic planning of ambulance demand, given its lengthy administrative processes involving feasibility study, impact assessment, public consultation, and legislative debates. For example, the Consultancy Study on Paramedic Ambulance Service in Hong Kong[18] conducted in 2001 projected needs into 2014. It was also observed that a feasibility study of the Ambulance Medical Priority Dispatch System was completed in 2005 by the Government,[19] but the project would not materialize until 2014.[20] Hence we made an attempt in this article to undertake a longer-term projection of the annual ambulance demand in 2036 by considering changes in the population demographics as well as weather effects, using 2008 as the base year. The projected weather effects on ambulance demand did not take into account possible weather conditions in 2036.

Nonetheless, biometeorologists can make use of the projected outcome to assess further impacts on the ambulance demand using different scenarios of the 2036 weather profile.

The Fire Services Department of Hong Kong is responsible for providing emergency ambulance services, whereas the Hospital Authority (HA) and a few voluntary organizations handle nonemergency ambulance calls. In 2010, the Ambulance Command that belongs to the Fire Services Department managed 36 ambulance depots distributed at different locations in Hong Kong served by a total of 2400 ambulance staff and a collection of service vehicles.[21] The number of ambulance calls continued to increase annually between 2006 and 2010 (539 903 → 573 657 → 600 828 → 617 265 → 646 733), with an average of 1882 calls a day in 2010. The rise in emergency ambulance demand for Hong Kong is a result both of population increase and ageing.

Materials and Methods

Ambulance Demand and Metrological Statistics

More than 2 million records of emergency attendance (from January 1, 2008, to December 31, 2008) at the accident and emergency departments of all hospitals managed by the HA were obtained for this study. Each record was anonymized and contained an arbitrary record number, age, gender, date, and an ambulance brought-in indicator.

Daily statistics of common weather variables (including daily average temperature, rainfall, and humidity) throughout the study period were obtained from the Web site of the Hong Kong Observatory.[22] These variables were measured at the observatory weather station, which is 1 of 2 manned weather stations located near the center of Hong Kong. Only daily average temperature was considered in this study because ambient temperature among different weather factors has the most significant effects on human health.[23,24] In addition, the average temperature value was squared to accentuate its "U" shaped relationship with ambulance demand that suggests increasing demand for ambulance services during colder and hotter days.

The proposed projection method was based on the age-gender population structure in 2008. Figure 1 shows that the yearly patterns of daily ambulance demand and average temperature in 2008 were comparable with the general trends within 2006-2009. Moreover, the data series of year 2008 had enough observations to establish regression equations in the study.[25] One year time-series data are preferred to multiyear data to avoid the need for data normalization, which could introduce artificial effects to contaminate the data series (such as masking significant differences and inappropriate choice of reference limits).[26] Hence, 1 year of data were used to preclude unwanted interference from population increase and other confounding factors involving multiyear data analysis.

Data Preprocessing

Data preprocessing is an essential step to clean imperfections and remove noise in the original data sets. In this study, we made attempts to eliminate random fluctuations of time-series data on temperature and also took into account time lag effects of weather on the daily ambulance calls.[11] In the former instance, we applied the technique of 3-day moving average on the data series to smooth out short-term fluctuations in temperature that, in turn, brought into focus the longer-term trend. In the latter situation, the variable of average temperature was shifted 4 days forward against the variable of daily ambulance demand on the same day to account for the time lag effect because reactions to abrupt temperature changes often occurred a few days after exposure.[6,11,27]

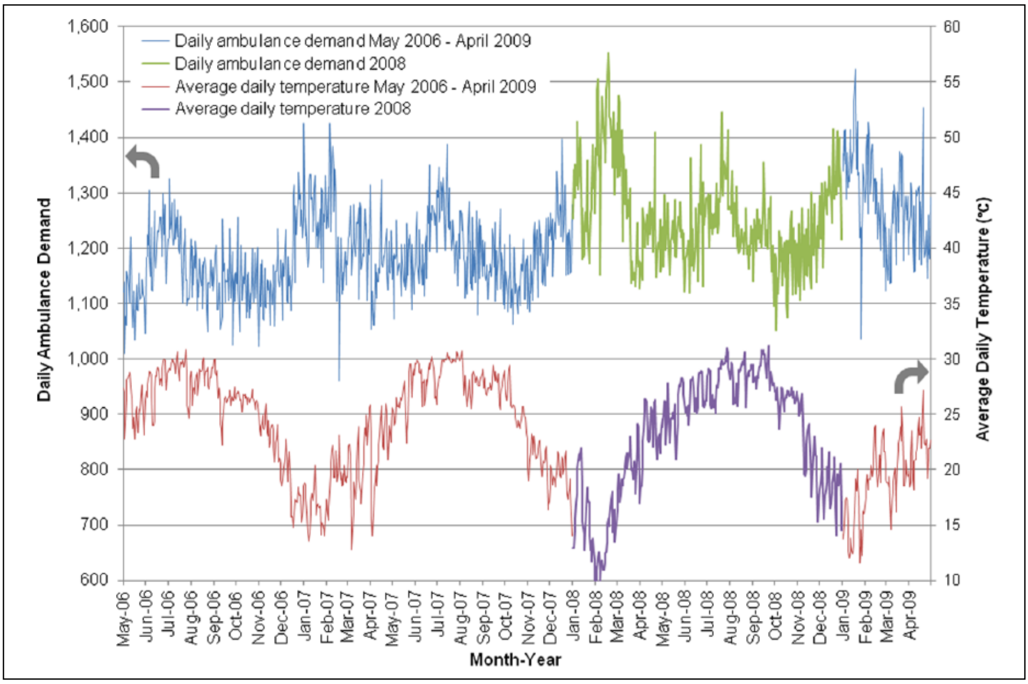

Figure 1. Data series of daily ambulance demand and average temperature, May 2006 to April 2009.

Methods

The age-gender population structure for Hong Kong was established for 2008 and 2036 based on data obtained from the census and statistics department.[28] The year 2036 was chosen because it was the furthest population projection provided by the department. Age-gender–specific weighting factors were computed by dividing the 2036 population numbers by their corresponding 2008 values. The projection was conducted in 2 stages.

In the first stage, all records of ambulance cases were aggregated by different age-gender groups. Two versions of projection models were attempted to project the ambulance demand in 2036: (1) without accounting for age-gender demographic changes and (2) accounting for age-gender demographic changes. In the first version, the projected figure for 2036 was obtained by multiplying the 2008 ambulance demand by the percentage increase in the total population between 2008 and 2036. Therefore,

$$Y_{2036} = \frac{2036 \text{ Population}}{2008 \text{ Population}}\left(Y_{2008}\right),$$

where Y_{2036} and Y_{2008} are the yearly ambulance demands in the respective years.

In the second version, the age-gender changes were considered as follows:

$$Y_{2036} = \sum_{i}\left(W_{i,\text{male}}Y'_{i,\text{male}} + W_{i,\text{female}}Y'_{i,\text{female}}\right),$$

where Y_{2036} is the yearly ambulance demand in 2036, $Y'_{i,\text{female}}$ is the ambulance demand for the ith age group for women in 2008; $W_{i,\text{female}}$ is the specific weighting factor for the ith age group for women; and $Y'_{i,\text{male}}$ and $W_{i,\text{male}}$ are the corresponding male equivalents, as defined above. The effects of age-gender structure on the predicted demand would be revealed by comparing differences between the base year and projected figures.

In the second stage, ambulance cases were first aggregated into daily ambulance demand statistics by different age-gender groups. The multiple linear regression models, as defined below, were used to set up a stack of age-gender–specific equations between average temperature and the daily ambulance demand.

$$Y_{i,\text{male}} = \beta_{0,i,\text{male}} + \beta_{1,i,\text{male}} T + \beta_{2,i,\text{male}} T^2$$

and

$$Y_{i,\text{female}} = \beta_{0,i,\text{female}} + \beta_{1,i,\text{female}} T + \beta_{2,i,\text{female}} T^2,$$

where $Y_{i,\text{male}}$ is the ambulance demand for the ith age group for men; $\beta_{0,i,\text{male}}$, $\beta_{1,i,\text{male}}$, and $\beta_{2,i,\text{male}}$ are regression coefficients for the male groups; T is the average temperature; and $Y_{i,\text{female}}$, $\beta_{0,i,\text{female}}$, $\beta_{1,i,\text{female}}$, and $\beta_{2,i,\text{female}}$ are the female equivalents as defined above.

The group of age-gender–specific equations was totaled into an all-age-groups equation that explained the total ambulance demand for Hong Kong in 2008. To project temperature effects on the daily ambulance demand in 2036, we applied to each age-gender group its corresponding weighting factors between 2008 and 2036 derived earlier and summed all the equations to arrive at the all-age-groups equation, as follows:

$$Y_{2036} = \sum_i W_{i,\text{male}} Y'_{i,\text{male}} + W_{i,\text{female}} Y'_{i,\text{female}} = \sum_i W_{i,\text{male}} \left(\beta_{0,i,\text{male}} + \beta_{1,i,\text{male}} T + \beta_{1,i,\text{male}} T^2\right) + W_{i,\text{female}} \left(\beta_{0,i,\text{female}} + \beta_{1,i,\text{female}} T + \beta_{2,i,\text{female}} T^2\right),$$

where Y_{2036} is the daily total ambulance demand in 2036, $Y'_{i,\text{male}}$ is the daily ambulance demand for the ith age group for men in 2008, $W_{i,\text{male}}$ is the weighting factor for the ith age group for men, and $Y'_{i,\text{female}}$, $W_{i,\text{female}}$, $\beta_{0,i,\text{female}}$, $\beta_{1,i,\text{female}}$, and $\beta_{2,i,\text{female}}$ are the female equivalents as defined above. The effects of changes in the age-gender structure between 2008 and 2036 on the relationship between temperature and the daily ambulance demand can be detected from differences between the all-age-groups equations for these 2 variables.

In short, the age-gender–specific weighting factors play a key role in adjusting for the age-gender demographic changes. This is because the weighting factor of a particular age-gender group is in fact the ratio of its projected population in 2036 and its actual population in 2008. Were the population of an age-gender group increased by 100%, the number of people at risk would also increase by 100%, and the age-gender–specific weighting factor would be 2. When this weighting factor was multiplied with the ambulance demand for the corresponding age-gender group, a 100% increase in the ambulance demand would result. In contrast, using a uniform weighting factor for every age-gender group would give rise to a similar proportion of increase for all age-gender groups, disregarding varying levels of population increase among the groups. In this instance, the disproportionately high increase in the elderly population or the potential ambulance users would not be accounted for fairly because its effects would be diluted by the stable and diminishing numbers of younger age groups.

Results

Projection of the Total Ambulance Demand in 2036

The census and statistics department has compiled the 2036 population projection for the territory.[28] A comparison of the population pyramids of 2008 to 2036 at 5-year intervals (Figure 2) reveals a demographic transition from the shape of a rhombus toward an inverted triangle. Of

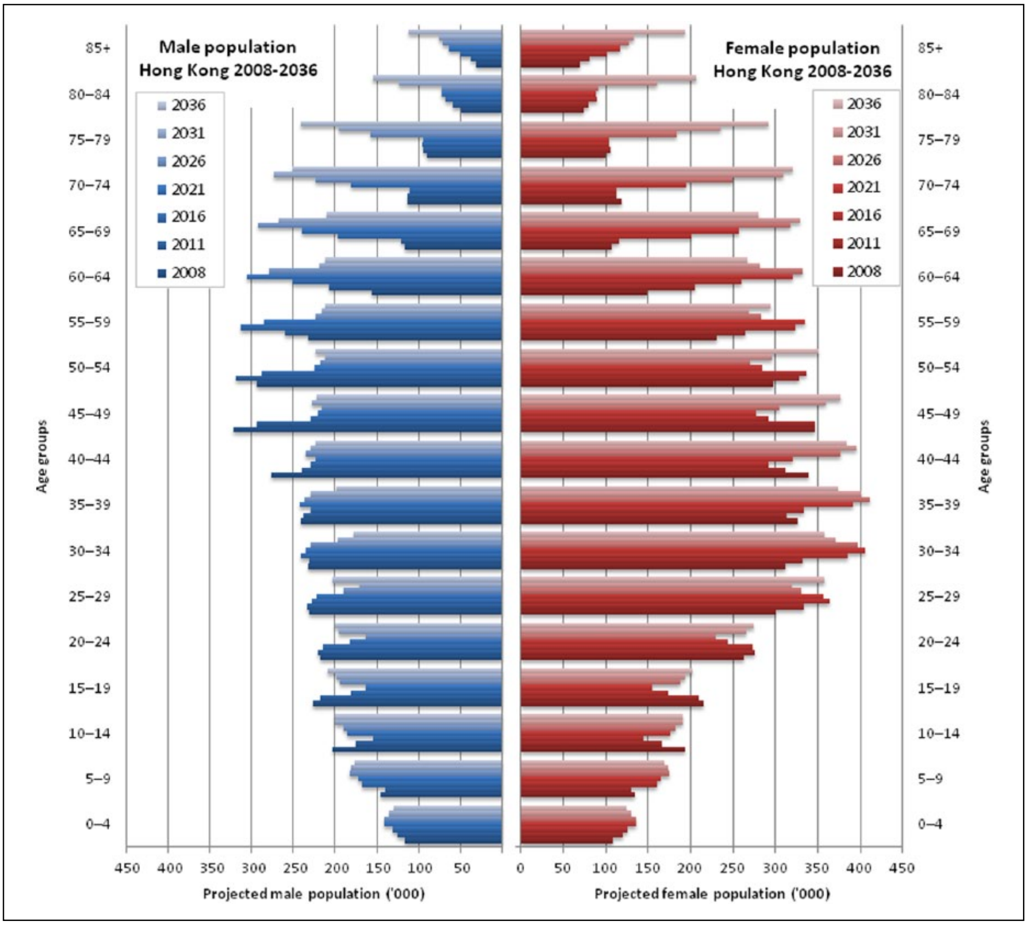

Figure 2. Population pyramids for 2008 to 2036 of Hong Kong at 5-year intervals.

particular concern is the sharp increase (2.5 times) in the 65 years and older age group, from 0.9 to 2.3 million, when the population in the age group younger than 65 years remained nearly constant at around 6 million. Moreover, it is expected that the female population will be significantly higher than the male population in 2036. This is mainly because of the presence of foreign domestic helpers and steady immigration of spouses living in Mainland China.[29] The consequence of changes in the age-gender structure goes beyond an exercise of making generalizations about groups of people; it has long-term economic, social, and political implications concerning equity, poverty, and quality of life.

The age-gender–specific weighting factors for Hong Kong are listed in Table 1. The projected population changes for the age group younger than 65 years are −11% and 16%, respectively, for the male and female population and 3% if taken altogether. However, the 65 and older age groups exhibit clear projected population increases ranging between 100% for men aged 65 to 74 years and 252% for men older than 85 years. Previous research has shown that elderly people are frequent users of ambulance services, and they are more prone to suffer from cold temperatures falling below 12°C, which is considered very cold in Hong Kong because most homes do not have heaters.[11] It appears that the projected demand for ambulance

Table 1. Age-Gender Specific Weighting Factors for 2036 (Using 2008 as the Base Year).

Age Group (years)	Male	Female	Both
0-64	0.89	1.16	1.03
65-74	2.00	2.66	2.33
75-84	2.84	2.87	2.86
85+	3.52	2.79	3.02
Total	1.08	1.36	1.23[a]

[a]Represents a 23% increase in the total population between 2008 and 2036.

Table 2. Ambulance Demand in 2008 and Projected Demand in 2036.

Age Group (years)	Ambulance Demand in 2008			2036 Projection Accounting for Changes in the Age-Gender Structure			2036 Projection Not Accounting for Changes in the Age-Gender Structure			Difference Between the 2 Projections		
	Male	Female	Both	Male	Female	Both	Male	Female	Both	Male	Female	Both
0-64	113 391	95 963	209 354	101 483	111 134	216 374[a]	139 471	118 034	257 505	37%	6%	19%
65-74	35 043	24 598	59 641	69 965	65 489	138 679[a]	43 103	30 256	73 358	−38%	−54%	−47%
75-84	54 086	56 673	110 759	153 767	162 665	316 560[a]	66 526	69 708	136 234	−57%	−57%	−57%
85+	25 683	53 175	78 858	90 498	148 108	237 900[a]	31 590	65 405	96 995	−65%	−56%	−59%
Total	228 203	230 409	458 612	415 713	487 397	909 514	280 690	283 403	564 093	−32%	−42%	−38%

[a]Only changes in age structure have been considered.

services would be grossly underestimated if the age-gender demographic transition between 2008 and 2036 was not considered.

Indeed, Table 2 confirms the above statement about the importance of age-gender structure in a projection model. The results show that a straightforward model without accounting for age-gender demographic changes between 2008 and 2036 consistently underestimated the 2036 ambulance demand for the elderly age groups of 65 years and more while overpredicting the needs of the age group younger than 65 years. The degree of underestimation was sizeable and ranged between −38% (men aged 65-74 years) and −65% (men aged >85 years) compared with overestimation at 6% (women aged 0-64 years) and 37% (men aged 0-64 years). An overall underestimation of −38% was reported for all age groups. Figure 3 shows the projected ambulance demand at a 5-year interval between 2011 and 2036. It is clear that projections that do and do not take into account the age-gender factor yield significantly different results. The disparity continues to widen further into the future.

Assessing Temperature Effects on Daily Ambulance Demand in 2036

The J- or U-shaped relationships between temperature and health effects (mortality or ambulance demand) were found in earlier studies.[8,11] Results of this study concur with earlier findings of the presence of a U-shaped relationship (see Figure 4). Table 3 shows that the groups aged 75 to 84 years and >85 years had a minimum adjusted R^2 value equal to 0.62 (women aged 75-84 years) and a maximum value of 0.76 (men aged 85+ years). The results also suggest that a large proportion of the daily ambulance demand from older age groups in Hong Kong could be explained by average temperatures. The curve of the overall temperature effect on the daily ambulance demand in 2008 is represented as line A in Figure 4.

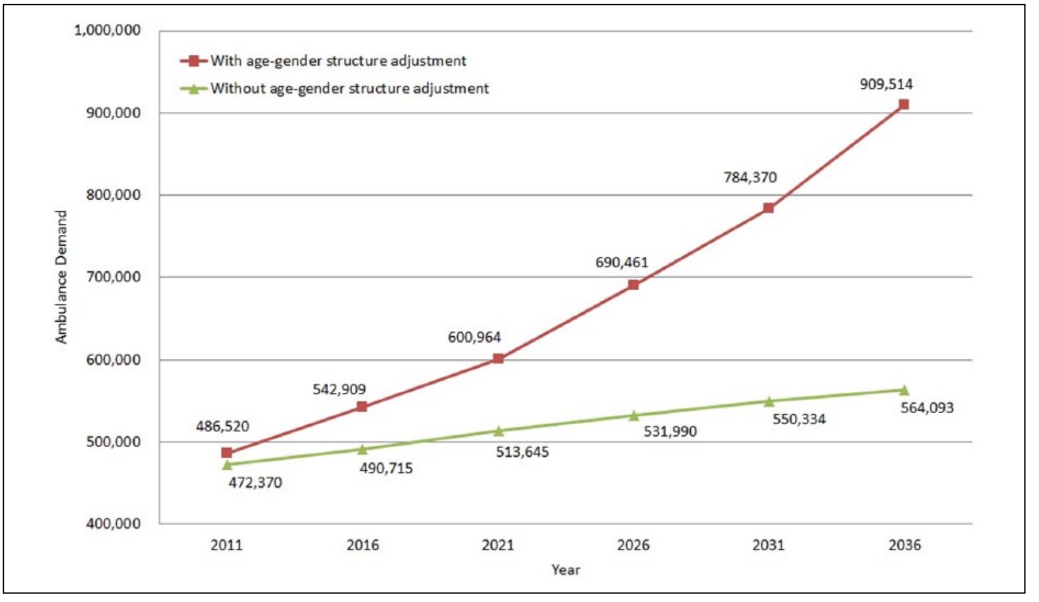

Figure 3. Projected yearly ambulance demand for 2011 to 2036 at 5-year intervals (accounting and not accounting for changes in the age-gender structure).

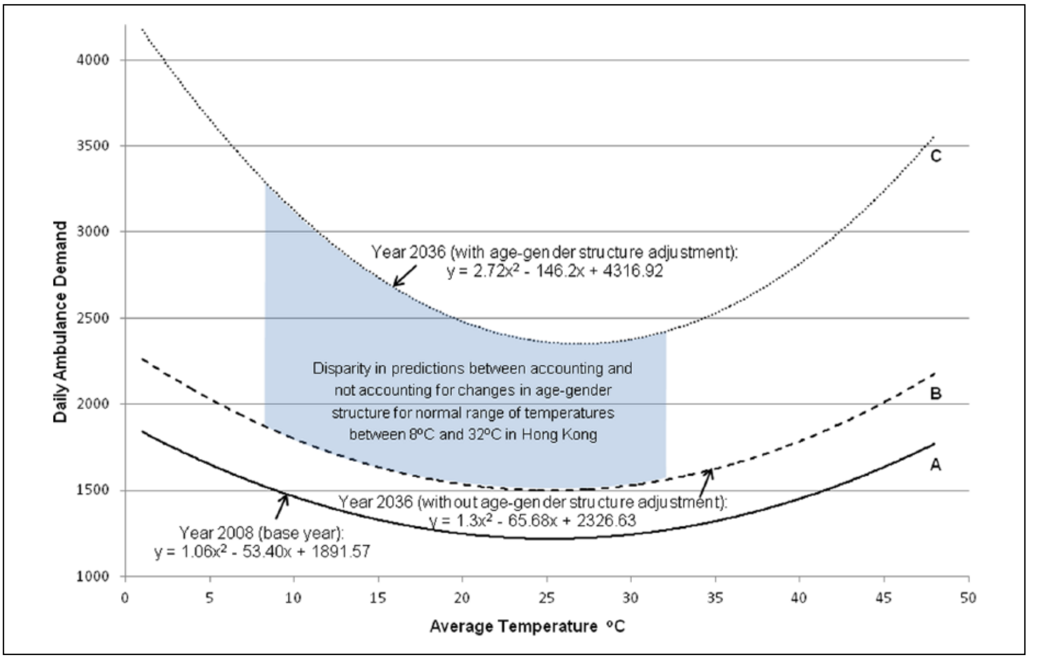

Figure 4. Projected weather effects on the daily ambulance demand in 2036 (accounting and not accounting for changes in the age-gender structure).

Table 3. Results of Regression Analysis Between Ambulance Demand for 2008 and Daily Average Temperature, T (on 4-Day Time Lag), by Gender and Age Groups.

Gender	Age Group (years)	Equations on 2008 Data	95%CI for T	95%CI for T^2	Adjusted R^2
Male	0-64	$282.57 + 0.35T + 0.04T^2$	−2.85, 3.27	−0.03, 0.10	0.23
	65-74	$165.12 - 5.72T + 0.11T^2$	−6.81, −4.64	0.09, 0.14	0.42
	75-84	$284.03 - 10.15T + 0.18T^2$	−11.75, −8.55	0.14, 0.21	0.69
	85+	$170.09 - 7.52T + 0.13T^2$	−8.49, −6.56	0.11, 0.15	0.76
Female	0-64	$271 - 3.29T + 0.12T^2$	−5.76, −0.82	0.06, 0.18	0.31
	65-74	$106.36 - 3.09T + 0.06T^2$	−3.96, −2.23	0.04, 0.08	0.32
	75-84	$291.85 - 10.95T + 0.21T^2$	−12.51, −9.39	0.17, 0.24	0.62
	85+	$320.56 - 13.01T + 0.22T^2$	−14.92, −11.11	0.18, 0.27	0.73
All age groups[a]		$1891.57 - 53.39T + 1.06T^2 \rightarrow A$	NA	NA	0.49

Abbreviation: CI, confidence interval.
[a]Obtained by summing the above equations.

Table 4. Results of Regression Analysis Between Projected Ambulance Demand for 2036 and Daily Average Temperature, T (on 4-Day Time Lag), by Age and Gender Groups.

		Equation on 2036 Projected Data	
Gender	Age Group (years)	With Age-Gender Structure Adjustment	Without Age-Gender Structure Adjustment
Male	0-64	$252.89 + 0.31T + 0.03T^2$	$347.56 + 0.42T + 0.04T^2$
	65-74	$329.67 - 11.43T + 0.22T^2$	$203.1 - 7.04T + 0.14T^2$
	75-84	$807.5 - 28.86T + 0.5T^2$	$349.36 - 12.49T + 0.22T^2$
	85+	$599.33 - 26.51T + 0.46T^2$	$209.21 - 9.25T + 0.16T^2$
Female	0-64	$313.84 - 3.81T + 0.14T^2$	$333.33 - 4.04T + 0.15T^2$
	65-74	$283.16 - 8.23T + 0.15T^2$	$130.82 - 3.8T + 0.07T^2$
	75-84	$837.68 - 31.43T + 0.59T^2$	$358.98 - 13.47T + 0.25T^2$
	85+	$892.86 - 36.25T + 0.62T^2$	$394.29 - 16.01T + 0.27T^2$
All age groups[a]		$4316.92 - 146.2T + 2.72T^2 \rightarrow C$	$2326.63 - 65.68T + 1.3T^2 \rightarrow B$

Abbreviation: CI, confidence interval.
[a]Obtained by summing the above equations.

Table 4 shows the stacks of age-gender–specific equations for 2036. Two columns are presented and they represent prediction equations with and without adjustment for changes in the age-gender structure. The overall temperature effects on the predicted daily ambulance demand in 2036 (with and without adjustment of demographic structures) are shown by lines B and C in Figure 4.

Lines A, B, and C show that temperature variation does affect the demand for ambulance services (Figure 4). The relationships are such that the ambulance demands tend to increase with colder and hotter temperatures at both ends. Lines B and C both represent the 2036 projected ambulance demand; the former without adjusting for age-gender demographic changes and the latter with adjustment. Although line B (which assumes a constant population increase for all age groups between 2008 and 2036) is an upward shift of line A, for line C (which echoes age-gender demographic changes between 2008 and 2036 as reflected in Figure 2 and Table 3) there is not only a larger upward shift of the ambulance demand, but the shape of the temperature-demand curve is also modified.

Discussions

Demand projections involving population have been criticized to be less than accurate primarily because of the linear or even simple curvilinear assumptions. Oversimplified projection models tend to give meaningless projections, and our proposed model demonstrated the necessity of considering the age-gender structure change in longer-term ambulance projection. More accurate demand projections will enable better resource planning in anticipation of future needs, so as to maintain current levels of services or reconsider future standards and expectations. Our study has demonstrated that adverse weather effects (with specific reference to extreme temperatures) do raise the demand for ambulance services, and the effect is exacerbated by the ageing population. Moreover, the value of including age-gender demographic changes improved the predictability of the projection model. The prediction model could be refined to accommodate temperature variation at both territorial (eg, the whole of Hong Kong) and local (eg, select districts in Hong Kong) scales. The results appeared reasonable because the increase in demand considering demographic changes in the age-gender structure was attributed largely to an increase in the elderly population who had a greater need for medical emergencies. Our study has also shown that the explained variance increased consistently with ageing (Table 3) and that age-gender structure and temperature were 2 important variables in estimating the demand for ambulance services.

Age-gender changes can be accommodated rather easily in a projection model, but their inclusion in general and specialty health service planning in Asia and many parts of the world has been generally overlooked.[30,31] Projections in these places have been largely a simple population ration exercise, which grossly underestimates needs of selected groups of the population. The exclusion of age-gender population changes in the projection yielded a projected underestimation figure of 38%. This discrepancy would result in overoptimism in the planning of future services and possibly also in other aspects of public utilities, resulting in substandard services or a need for drastic policy changes or budget reshuffling. More accurate prediction would enable better planning to provide sufficient resources for maintaining the same level of service standards or for devising new infrastructure to meet new and improved service capacities.

Research on longer-term projection of ambulance demand has been limited, but 2 recent studies have been identified. Although it was not for very long term, Lowthian et al[32] modeled, by means of regression analysis, the ambulance demand of metropolitan Melbourne in 2014/2015 using data from 1994/1995 to 2007/2008. Their analysis based on projected population numbers and demographic characteristics from government sources also revealed that an increase in the ambulance demand was generally greater among the older patients. Another study by Sasaki et al[33] made use of ambulance records from April to December 2007 and projected population census for Niigata City in Japan to estimate, by means of regression analysis, the ambulance demand from 2015 to 2040 in 5-year intervals. Their study found that the "number of companies with more than five employees" was a significant positive determinant for ambulance demand. This result suggested that there might be room to improve longer-term projection of ambulance demand besides the consideration of the age-gender structure.

Not controlling for certain biases and confounders was a limitation of this study and might have affected the estimated ambulance demand. For example, the 2006-2008 cases of ambulance misuse (ie, transported cases classified as semiurgent, nonurgent, or unclassified by the Accident and Emergency Triage Categorization System of the HA) made up 38.3% of the total patients.[31] If the Government of Hong Kong were to impose a user fee policy in the future to deter abusers of free-ride ambulance services, future ambulance demand would probably be lower than the projected figures because the abuse of ambulance as free taxi service would be stopped and nonessential or nonurgent users would think twice about calling for ambulance transport. Moreover, the potential use of telemedicine system for home monitoring and availability of alternative means of transportation to hospitals might also render the projection less accurate. On the other hand, new and emerging infectious diseases would pose increasing threat to human health that might necessitate attendance by professional paramedics before arrival at a hospital. The trend of increasing frequencies in food and drug poisoning as evident over the past decade[34] might also increase the burden of ambulance services. Given that it is difficult to account for these confounders that either favor or counter the effects of each other, they were not included in the research.

Conclusion

Although the world has begun to face more serious weather changes, actions against climate change have been slow in coming. Guiding principles to prepare and plan for health services in anticipation of climate change is essential to a city's sustainability.[35,36] Our study has demonstrated the need to account for weather effects and population demographics in deriving more accurate projections of the long-term demand for emergency ambulance services in Hong Kong. Collecting and promoting long-term surveillance data on morbidity caused by temperature extremes and other potential health issues will improve the characterization of weather-health relationships. More research is needed to better define the temperature lines to alert not only the service providers but also users by each age and gender group. Furthermore, proper education and health support measures at the community level can also help reduce unnecessary calls for ambulance services and emergency consultation.

Authors' Note

Ethical approvals (EA320110 and EA040710) were obtained from the University of Hong Kong Human Research Ethics Committee for Non-Clinical Faculties.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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