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. Over 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 considering 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 2008-2036 age-gender structure also shift upward and emphasise 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.

Key words: 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 as the older population is the likely contributor to the growing demand for health services and emergency ambulance attendance. It was estimated that within the period from 1996 to 2001, 25% of growth in ambulance services 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 need given the growing prevalence of chronic medical conditions and a higher incidence of age-related acute illnesses.[4] Compared to 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 about an ongoing process of decline in the physical health conditions more than just isolated health incidents. Studies have also indicated that many of the emergency episodes involving the elderly 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 the elderly in 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 and above age group (adjusted-R^2=0.49) but not for other age groups of 0-24 and 25-44 by using monthly data from 1980 to 1994.[8] Excess mortality has been attributed to extreme temperatures culminating obstructive cardiovascular and respiratory conditions. Under extreme weather, abrupt changes in the body temperature increase the symptoms of chronic pulmonary disease resulting in greater utilisation of medical services, including ambulance transfers, emergency visits, or hospitalisation.[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 and above (adjusted-R^2=0.71) but not for the remaining age groups.

Kan et al. 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.[12] 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 ageing population, these research findings signal possible worsening of future situation 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 characterisation 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 one-year ahead projection.[14,15] A short-term projection of about 5-10 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 materialise until 2014.[20] Hence, we made an attempt in this paper 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, bio-meteorologists can make use of the projected outcome to assess further impacts on the ambulance demand using different scenarios of 2036 weather profile.

The Fire Services Department (FSD) of Hong Kong is responsible for providing emergency ambulance services whereas the Hospital Authority (HA) and a few voluntary organisations handle non-emergency ambulance calls. In 2010, the Ambulance Command that belongs to the FSD 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

Over 2 million records of emergency attendance (from 01 January 2008 to 31 December 2008) at the Accident and Emergency Departments of all hospitals managed by the HA were obtained for this study. Each record was anonymised 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, humidity) throughout the study period were obtained from the website of the Hong Kong Observatory (HKO).[22] These variables were measured at the HKO weather station which is one of the two manned weather stations located near the centre of Hong Kong. Only daily average temperature was considered in this study as 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" shape relationship with ambulance demand that suggests increasing demand for ambulance services in days of colder and hotter temperatures.

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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 daily 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 is preferred to multi-year data to avoid the need for data normalisation which could introduce artificial effects to contaminate the data series (such as masking significant differences and inappropriate choice of reference limits).[26] Hence, one year of data was used to preclude unwanted interference from population increase and other confounding factors involving multi-year data analysis.

- Insert Figure 1 -

Data Pre-processing

Data pre-processing is an essential step to clean imperfections and remove noise in the original data sets. In this research, 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 demand[11] In the former instance, we applied the technique of three-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 at 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]

Methods

The age-gender population structure for Hong Kong was established for 2008 and 2036 based upon 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 two 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: (i) without accounting for age-gender demographic changes, and (ii) 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,

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

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

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

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

Y_{2036} is the yearly ambulance demand in 2036;

$Y'_{i,female}$ is the ambulance demand for the ith age group for female in 2008;

$W_{i,female}$ is specific weighting factor for the ith age group for female; and

$Y'_{i,male}$ and $W_{i,male}$ are the 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.

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

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

$Y_{i,\,male}$ is ambulance demand for the ith age group for male;

$\beta_{0,i,male}$, $\beta_{1,i,male}$ and $\beta_{2,\,i,\,male}$ are regression coefficients for the male groups;

T is average temperature; and

$Y_{i,\,female}$, $\beta_{0,i,female}$, $\beta_{1,i,female}$ and $\beta_{2,\,i,\,female}$ are the female equivalents as defined above.

The group of age-gender specific equations was totalled 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 of the equations to arrive at the all age-groups equation, as follows:

$$Y_{2036} = \sum_i W_{i,male}Y'_{i,male} + W_{i,female}Y'_{i,female}$$

$$= \sum_i \begin{bmatrix} W_{i,male}\left(\beta_{0,i,male} + \beta_{1,i,male}T + \beta_{1,i,male}T^2\right) + \\ W_{i,female}\left(\beta_{0,i,female} + \beta_{1,i,female}T + \beta_{2,i,female}T^2\right) \end{bmatrix} \text{; where}$$

Y_{2036} is the daily total ambulance demand in 2036;

$Y'_{i,\,male}$ is the daily ambulance demand for the ith age group for male in 2008;

$W_{i,male}$ is the weighting factor for the ith age group for male; and

$Y'_{i, female}$, $W_{i, female}$, $\beta_{0, i, female}$, $\beta_{1, i, female}$ and $\beta_{2, i, female}$, 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 two 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 groups 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 of the elderly population or the potential ambulance users would not be accounted 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 & Statistics Department has compiled the 2036 population projection for the territory.[28] A comparison of the population pyramids of 2008 to 2036 at five year intervals (Figure 2) reveals a demographic transition from the shape of a rhombus towards an inverted triangle. Of particular concern is the 2.5 times sharp increase of the 65 and above age groups from 0.9 to 2.3 million when the below 65 age groups remain about 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 due to 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 generalisations about groups of people; it has long-term economic, social, and political implications concerning equity, poverty and quality of life.

-    Insert Figure 2   -

The age-gender specific weighting factors for Hong Kong are listed in Table 1. The projected population changes for the below 65 age groups 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 males aged 65-74 and 252% for males aged 85+. 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 ºC which is considered very cold in Hong Kong because most homes are

without heaters.[11] It appears that the projected demand for ambulance services would be grossly underestimated if the age-gender demographic transition between 2008 and 2036 was not considered.

- Insert Table 1 -

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 and above while over-predicting the needs of the below 65 age group. The degree of underestimation was sizeable and ranged between -38% (male aged 65-74) to -65% (male aged 85+) compared to overestimation at 6% (female aged 0-64) and 37% (male aged 0-64). 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 considering and not considering for the age-gender factor yield significantly different results. The disparity continues to widen further into the future.

- Insert Table 2 -
- Insert Figure 3 -

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 75-84 and 85+ had a minimum

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adjusted-R^2 value equals to 0.62 (female aged 75-84) and a maximum value equals to 0.76 (male aged 85+). 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.

-   Insert Table 3   -

-   Insert Figure 4   -

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 curve of the overall temperature effects on the predicted daily ambulance demand in 2036 (with and without adjustment of demographic structures) are drawn as lines B and C in Figure 4.

-   Insert Table 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 otherwise. Although Line B (that assumes a constant population increase for all age groups between 2008 and 2036) is an upward shift of Line A, Line C (which echoes age-gender demographic changes between 2008 and 2036 as reflected in Figure 2 and Table 3) not only incurs a larger upward shift of the ambulance demand but also modifies the shape of the temperature-demand curve.

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DISCUSSION

Demand projections involving population have been criticised to be less than accurate primarily because of the linear or even simple curvilinear assumptions. An oversimplified projection model tends to yield meaningless projection with larger than expected errors. Our proposed model has demonstrated the merits of including age and gender effects in moderating errors for longer term projections. 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 (e.g. the whole of Hong Kong) and local (e.g. 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 two important variables in estimating the demand for ambulance services.

Age-gender changes can be accommodated rather easily in a projection model but its 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

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under-estimates needs of selected groups of the population. The exclusion of age-gender population changes in the projection yielded a projected figure of 38% underestimation. This discrepancy would result in over optimism 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 in maintaining the same level of service standards or devise new infrastructures in meeting new and improved service capacities.

Research on longer term projection of ambulance demand was few but two recent studies have been identified. Although not for very long term, Lowthian et al modelled, by means of regression analysis, the ambulance demand of metropolitan Melbourne in 2014/15 using data from 1994/95 to 2007/08.[32] 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. 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.[33] 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 age-gender structure.

Lacking the control of certain biases and confounders was a limitation of the research that might have affected the estimated ambulance demand. For example, the 2006-2008 cases of ambulance misuse (i.e., transported cases

classified as semi-urgent, non-urgent or unclassified by the Accident & Emergency Triage Categorization System of the Hospital Authority) 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 non-essential or non-urgent 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 favour or counter effects of each other, they were not included in the research.

CONCLUSION

Although the world has begun to face weather changes more seriously, actions against climate change have been slow in forthcoming. 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 due to temperature extremes and other potential health issues will

improve the characterisation 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 groups. Furthermore, proper education and health support measures at the community level can also help reduce unnecessary calls for ambulance services and emergency consultation.

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COMPETING INTEREST

None to declare.

ETHICAL CONSIDERATIONS

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

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       pp. 133S-143S.

Table caption

1　Age-gender specific weighting factors for 2036 (using 2008 as the base year)

2　Ambulance demand in 2008 and projected demand in 2036

3　Results of regression analysis between 2008 ambulance demand and daily average temperature (on 4-day time lag) by gender and age groups

4　Results of regression analysis between 2036 projected ambulance demand and daily average temperature (on 4-day time lag) by age and gender groups

Figure caption

1　Data series of daily ambulance demand and average temperature, May 2006 - April 2009

2　2008 to 2036 population pyramids of Hong Kong at five year intervals

3　2011 to 2036 projected yearly ambulance demand at five year intervals (accounting and not accounting for changes in the age-gender structure)

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

Table 1   Age-gender specific weighting factors for 2036 (using 2008 as the base year)

Age group	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[†]

† 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	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 two 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[†]	139,471	118,034	257,505	37%	6%	19%
65-74	35,043	24,598	59,641	69,965	65,489	138,679[†]	43,103	30,256	73,358	-38%	-54%	-47%
75-84	54,086	56,673	110,759	153,767	162,665	316,560[†]	66,526	69,708	136,234	-57%	-57%	-57%
85+	25,683	53,175	78,858	90,498	148,108	237,900[†]	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%

† Only changes in age-structure have been considered.

Table 3   Results of regression analysis between 2008 ambulance demand and daily average temperature (on 4-day time lag) by gender and age groups

Gender	Age group	Equations on 2008 data	95%CI for T	95%CI for T^2	adj-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†		$1891.57 - 53.39T + 1.06T^2$ → A	n.a.	n.a.	0.49

†   Obtained by summing the above equations.

Table 4 Results of regression analysis between 2036 projected ambulance demand and daily average temperature (on 4-day time lag) by age and gender groups

Gender	Age group	Equation on 2036 projected data	
		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 [†]		$4316.92 - 146.2T + 2.72T^2$ → C	$2326.63 - 65.68T + 1.3T^2$ → B

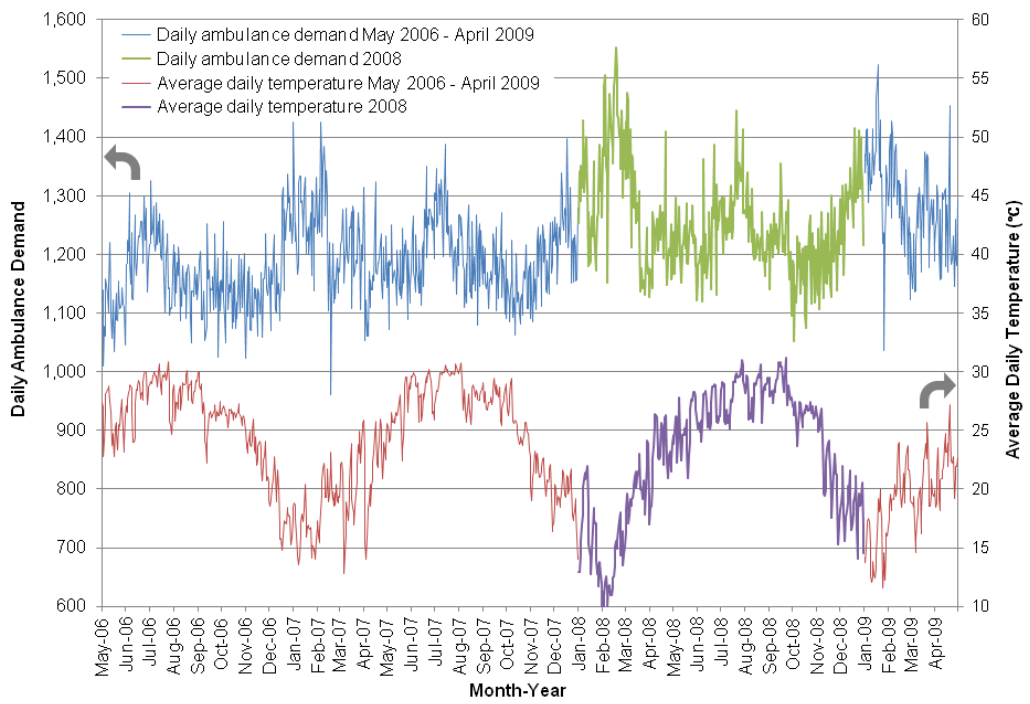† Obtained by summing the above equations.

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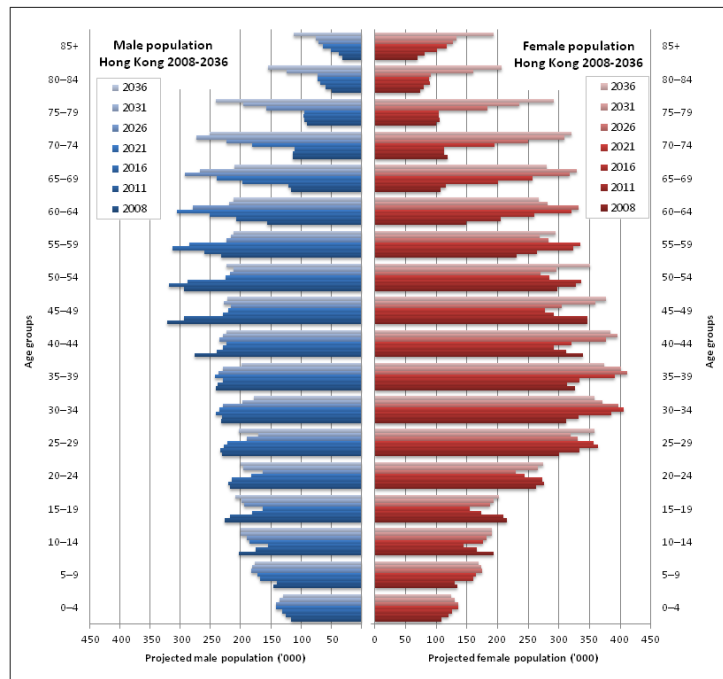
May 2006 - April 2009

Figure 2   2008 to 2036 population pyramids of Hong Kong at five year
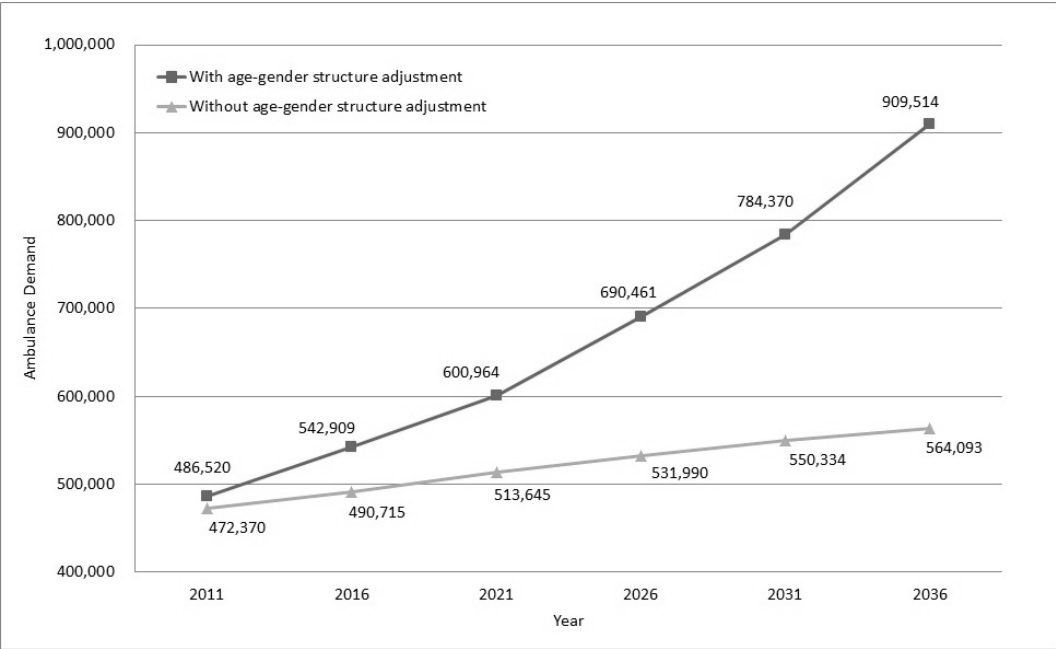
intervals

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

The chart shows curves of Daily Ambulance Demand (y-axis, 1000 to 4000) versus Average Temperature °C (x-axis, 0 to 50).

Curve C (dotted): Year 2036 (with age-gender structure adjustment):
$y = 2.72x^2 - 146.2x + 4316.92$

Curve B (dashed): Year 2036 (without age-gender structure adjustment):
$y = 1.3x^2 - 65.68x + 2326.63$

Curve A (solid): Year 2008 (base year):
$y = 1.06x^2 - 53.40x + 1891.57$

Disparity in predictions between accounting and not accounting for changes in age-gender structure for normal range of temperatures between 8ºC and 32ºC in Hong Kong
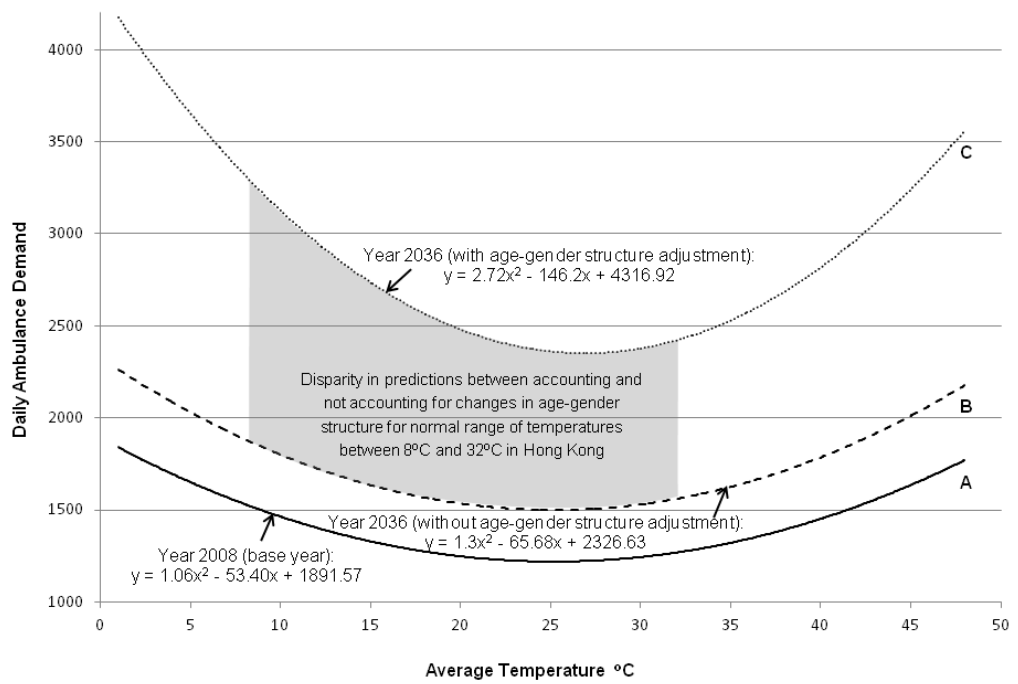
Figure 4   Projected weather effects on the daily ambulance demand in 2036 (accounting and not accounting for changes in the age-gender structure)