For discussion on
24 March 2021

Legislative Council Panel on Health Services

Updates of the Study on Healthcare Manpower Projection

PURPOSE

This paper reports to Members on the results of the latest round of commissioned study on Healthcare Manpower Projection being conducted by the University of Hong Kong ("HKU").

BACKGROUND

2. The Government published the report of the Strategic Review on Healthcare manpower Planning and Professional Development in June 2017 ("the 2017 Report"), setting out ten recommendations to lay the foundation for healthcare manpower planning and the direction for professional development and regulation of healthcare professionals, with a view to ensuring that there were qualified healthcare professionals to support the healthy and sustainable development of the healthcare system in Hong Kong.

3. Among these recommendations, one of them was that the Government should conduct manpower planning and projections for healthcare professionals once every three years in step with the triennial planning cycle of the University Grants Committee ("UGC"). The Government has commissioned HKU to conduct a new round of manpower projection exercise to update the demand and supply projections of healthcare professionals, including doctors, dentists and dental hygienists, nurses and midwives, Chinese medicine practitioners, pharmacists, occupational therapists, physiotherapists, medical laboratory technologists, optometrists, radiographers and chiropractors.

4. The Food and Health Bureau briefed the Legislative Council Panel on Health Services before on 13 December 2019 (LC Paper No. CB(2)

349/19-20(03) at **Annex A**) on the background of the projection, and the interval progress of the manpower projection study.

PROJECTION RESULTS, OBSERVATIONS AND RECOMMENDATIONS

5. The projection results of all the above thirteen professions can be found in the Executive Summary of the present projection (Base year 2017) as attached in **Annex B**. Externalities and policy options for individual professions, as well as opinions expressed by stakeholder groups. These groups include Hospital Authority, Department of Health, representatives from universities, regulatory Boards and Councils, professional organisations and private sector representatives. The series of engagement sessions conducted in 2020 with each of the professions concerned have been incorporated. Interpretations and observations from these projection results are also contained in the Executive Summary.

6. Projection results showed shortages in the following professions:

(a) Doctors

(i) When compared with the previous projection as in "the 2017 Report", manpower shortage of doctors persists, and the gap further widens in both short- and medium-term;

(ii) The manpower gap is projected to be 1 610, 1 700 and 1 949 respectively in year 2030, 2035 and 2040;

(iii) Regarding the public sector specifically, the shortage of doctors in the Hospital Authority is projected to be 660, 800 and 960 in 2020, 2030 and 2040 respectively;

(iv) Initiatives to increase supply of both locally and non-locally trained doctors will be continued, including further increase in local medical training places, recruiting and retaining doctors working in the public sector, and to prepare for the legislation of admitting non-locally trained doctors who are permanent residents of Hong Kong.

(b) Dentists

(i) It is projected that a manpower shortage of dentists will

be seen in short- and medium-term, and the shortage will be less significant towards the end of the projection horizon. This is the result of the measures to increase supply of dentists that have been implemented;

(ii) The manpower gap is projected to be 115, 102 and 0 respectively in year 2030, 2035 and 2040;

(iii) Additional UGC-funded training places are recommended in the coming triennium.

(c) Nurses (General)

(i) When compared with the previous projection, manpower gap further widens for general nurses in short- and medium-term, reflecting the growing demand from both medical and welfare sectors and from existing and newly planned services, despite measures to significantly increase the supply of general nurses that have been in place. Growing service demands on public hospitals widen the manpower gap further. The welfare sector is also experiencing steadily growing service demand expected on nurse manpower when new initiatives such as planned elderly and rehabilitation services are implemented;

(ii) The manpower gap is projected to be 3 679, 4 337 and 5 060 respectively in year 2030, 2035 and 2040;

(iii) Regarding the public sector specifically, the shortage of nurses in Hospital Authority is 3 020, 3 720 and 4 480 in year 2020, 2030 and 2040 respectively;

(iv) Further increase in UGC-funded or self-financing training places is recommended in the coming triennium.

(d) Physiotherapists

(i) A shortfall of physiotherapists is noted in short- and medium-term, as a result of increasing demand in both medical and welfare sectors, though the gap narrows compared with the last projection exercise;

(ii) The manpower gap is projected to be 276, 366 and 487 respectively in year 2030, 2035 and 2040;

(iii) There will be additional graduates from Open University of Hong Kong and Caritas Institute of Higher Education starting year 2024.

(e) Medical Laboratory Technologists (MLTs)

(i) Taking into account the extra surge in demand for healthcare services in both public and private sectors as a result of COVID-19, a significant increase in MLTs manpower shortage of is anticipated in both short- and medium-term, provided that prevailing outbreak persists;

(ii) The manpower gap is projected to be 153, 182 and 328 respectively in year 2030, 2035 and 2040;

(iii) Further increase in UGC-funded training places is recommended in the coming triennium.

(f) Optometrists

(i) Supply of optometrist drops substantially from 2017 onwards as a result of cohort retirement, increasing the manpower gap along the projection horizon. The demand is projected to peak at year 2035 and decline thereafter. As the majority of optometrists are in private practice, some degree of supply flexibility exist due to variable retirement age and work patterns;

(ii) The manpower gap is projected to be 366, 480 and 654 respectively in year 2030, 2035 and 2040;

(iii) Further increase in UGC-funded training places is recommended in the coming triennium.

(g) Radiographers

(i) A narrowing in manpower gap for radiographers is projected in the short-term, partly due to the increased supply since 2016 from Tung Wah College. However, shortage for radiographers in the diagnostic stream remains significant from year 2028 onwards, despite a short-term slight surplus, and more evident than those in the therapeutic stream, due to increasing demand from both public and private sectors;

(ii) The manpower gap is projected to be 59, 190 and 233 respectively in year 2030, 2035 and 2040;

(iii) Further increase in UGC-funded training places is recommended in the coming triennium.

7. On the other hand, projection results revealed adequate manpower supplies in the following professions:

(h) Dental hygienists

(i) The manpower gap is projected to be -68, -144 and -185 respectively in year 2030, 2035 and 2040;

(ii) There is an adequate supply of dental hygienists.

(i) Nurses (Psychiatric)

(i) The manpower gap is projected to be -167, -427 and -716 respectively in year 2030, 2035 and 2040;

(ii) The manpower gap of psychiatric nurses becomes narrowed in the medium-term comparing to the last projection, largely as a result of increasing demand for psychiatric nurses in both medical and welfare sectors.

(j) Midwives

(i) The manpower gap is projected to be -1 710, -1 612 and -1 250 respectively in year 2030, 2035 and 2040;

(ii) Midwife demand is based on utilisation volume of pre-natal and live birth services, and related to the number of

newborns. At this moment, the total number of registered midwives should be adequate for the years to come, given there are training for the new entries each year from local post-registration diploma course, despite an anticipated retirement wave in the coming decade.

(k) Chinese Medicine Practitioners (CMPs)

(i) The manpower gap is projected to be -1 671, -1 642 and -1 458 respectively in year 2030, 2035 and 2040;

(ii) The demand in the private sector remains stable. An adequate manpower of CMPs are projected in both short- and medium-term, with a narrowing of manpower gap in the long-term.

(l) Pharmacists

(i) The manpower gap is projected to be -330, -502 and -652 respectively in year 2030, 2035 and 2040;

(ii) The demand on public hospitals inpatient, specialty outpatient and general outpatient dispensing services are all growing along the projection horizon, especially those for inpatients. An adequate manpower of pharmacist however, are projected in both short- and medium-term in the present projection from year 2020 onwards. This is in commensurate with the decrease in demand of community pharmacists due to economic downturn and a reduced demand from tourists, whereas the supply for local graduates remains steady.

(m) Occupational therapists

(i) The manpower gap is projected to be -336, -489 and -536 respectively in year 2030, 2035 and 2040;

(ii) Demand for occupational therapists is continuously rising in both medical and welfare sectors. Given the increased number of graduates from Tung Wah College additionally started year 2017, making the manpower supply of occupational therapists adequate.

(n) Chiropractors

(i) The manpower gap is projected to be -111, -145 and -172 respectively in year 2030, 2035 and 2040;

(ii) The supply of chiropractors is adequate in both short- and medium-term from year 2020 onwards due to increasing number of new registrants graduated from overseas. The growth in demand remains slow on the other hand.

NEXT STEPS

8. To further refine the manpower planning and projection, HKU has started to conduct manpower projection for specialist doctors and later extend to specialist dentists, and also to differentiate workforce skills mix for registered nurses ("RN") and enrolled nurses ("EN") in order to conduct manpower projection for RN and EN.

9. The full healthcare manpower review report, including those new features mentioned in 8. above will be promulgated in the third quarter of 2021.

ADVICE SOUGHT

10. Members are invited to note the content of this paper.

Food and Health Bureau
March 2021

Annex A

For discussion on
13 December 2019

Legislative Council Panel on Health Services

Healthcare Manpower Projection 2020

PURPOSE

This paper briefs Members on the Healthcare Manpower Projection 2020 being conducted by the University of Hong Kong ("HKU").

BACKGROUND

2. In 2012, the Government set up a high-level steering committee (chaired by the then Secretary for Food and Health) to conduct the Strategic Review on Healthcare Manpower Planning and Professional Development ("Strategic Review"). To assist the steering committee in making informed recommendations to the Government, we commissioned HKU to conduct a comprehensive manpower projection for the 13 healthcare professions which are subject to statutory registration, including doctors, dentists and dental hygienists, nurses and midwives, Chinese medicine practitioners ("CMPs"), pharmacists, occupational therapists ("OTs"), physiotherapists ("PTs"), medical laboratory technologists ("MLTs"), optometrists, radiographers and chiropractors.

3. The Government published the report of the Strategic Review in June 2017, setting out ten recommendations to lay the foundation for healthcare manpower planning and the direction for professional development and regulation of healthcare professionals, with a view to ensuring that there are qualified healthcare professionals to support the healthy and sustainable development of the healthcare system in Hong Kong. One of the recommendations is that the Government should conduct manpower planning and projections for healthcare professionals once every three years in step with the triennial planning cycle of the

University Grants Committee ("UGC").

4. Against the above background, the Government has commissioned HKU to conduct a new round of manpower projection exercise to update the demand and supply projections of the 13 healthcare professions.

THE PROJECTION MODEL

5. In the previous manpower projection exercise, HKU developed a generic forecasting model that suits the local circumstances and could be adaptable to cater for differences in utilisation patterns among individual professions. The Food and Health Bureau ("FHB") briefed the Legislative Council ("LegCo") Subcommittee on Health Protection Scheme under the Panel on Health Services on the manpower projection model developed by HKU on 15 April 2014 (LC Paper No. CB(2) 1283/13-14(01) at **Annex A**).

6. The same model will be used in the new manpower projection exercise. Under this model, the demand at the base year (i.e. 2017) is assumed to be at equilibrium, and takes into account known shortage in the public and subvented sectors for healthcare professionals as at end 2017. Future demand is derived with regard for demographic changes and other relevant factors including externalities and policy interventions through a sophisticated computer model, to which known and planned services and developments are incorporated. Future supply is derived from existing and planned local programmes as well as new registrants holding non-local qualifications. The demand projections so derived will then be compared with the estimated supply of healthcare professionals during the same period to see if any surplus or shortage of manpower exists. Details of the current projection model are set out at **Annex B**.

NEW FEATURES OF THE PRESENT PROJECTION EXERCISE

7. HKU will address in the present exercise some specific requirements of various healthcare professions suggested during the last

round of manpower projection. For instance, HKU will attempt to (a) conduct manpower projection for specialist doctors and dentists; and (b) differentiate workforce skills mix for registered nurses ("RN") and enrolled nurses ("EN") in order to conduct manpower projections for RN and EN respectively.

NEXT STEPS

8. HKU is now collating profession-specific service utilisation data for the purpose of making projections. FHB and HKU will conduct engagement sessions with all the 13 professions. Feedback from stakeholder groups will be incorporated in the projection exercise as appropriate. We expect the projection exercise to be completed before end 2020.

9. Subject to the findings of the manpower projection, the Government will consider whether to further increase the number of healthcare training places in the next UGC triennium and formulate relevant policies on sustaining the manpower of the healthcare professions.

ADVICE SOUGHT

10. Members are invited to note the content of this paper.

Food and Health Bureau
December 2019

For discussion
on 15 April 2014

Legislative Council Panel on Health Services
Subcommittee on Health Protection Scheme

Strategic Review on Healthcare Manpower Planning and Professional Development – Commissioned Study on Projecting Demand and Supply for Healthcare Professionals

PURPOSE

This paper briefs Members on a healthcare manpower projection model developed by the University of Hong Kong (HKU) for the purpose of the strategic review on healthcare manpower planning and professional development.

BACKGROUND

2. As part of our on-going efforts to reform the healthcare system, a high-level steering committee was established in 2012 to conduct a strategic review on healthcare manpower planning and professional development in Hong Kong. Chaired by the Secretary for Food and Health, the steering committee is tasked to formulate recommendations on how to cope with anticipated demand for healthcare manpower, strengthen professional training and facilitate professional development, with a view to ensuring the healthy and sustainable development of our healthcare system. To assist the steering committee in making informed recommendations, we have commissioned HKU to conduct a comprehensive manpower projection for the 13 healthcare professions which are subject to statutory regulation.

3. At the meeting of the Subcommittee on Health Protection Scheme on 11 November 2013, we briefed Members on the common approaches adopted in overseas jurisdictions for forecasting healthcare manpower as well as the constraints and challenges of healthcare workforce planning. We also informed Members of a generic forecasting model being developed by HKU for projecting healthcare manpower in Hong Kong and undertook to provide further details when available.

THE PROJECTION MODEL

4. HKU has completed construction of the manpower projection model for doctors. At the **Annex** is a technical paper produced by HKU explaining the workings of the complex model. In a nutshell, the model seeks to forecast demand for doctors in the planning horizon by projecting healthcare services utilisation of the population to be served using historical utilisation data which are further adjusted for population growth and demographic changes. The demand projections so derived will then be compared with the estimated supply of doctors during the same period to see if any surplus or shortage of manpower exists. The model will be suitably adapted to cater for utilisation parameters peculiar to individual professions in forecasting the manpower demand and supply situation of the other healthcare disciplines under study.

ADVICE SOUGHT

5. Members are invited to note the content of this paper.

Food and Health Bureau
April 2014

Annex

Projecting Demand and Supply for Doctors

1 Modelling of Hong Kong healthcare manpower

The overall model for Hong Kong doctor manpower projection comprises two sub models, the demand model and the supply model. Building on an endogenous, historically-informed base case scenario (where current utilisation (proxying demand) and supply are assumed to be in equilibrium), this model can be adopted to adjust for the impact of externalities such as: 1) de novo (i.e. exogenous) additional new hospital capacity (new public and private hospital in-patient beds) over and above endogenous historical growth and 2) the proposed new Health Protection Scheme. The difference between the demand and supply projections (in terms of total FTE numbers, accumulative and annual incremental FTE from 2012-2041) is the manpower 'gap' or 'surplus/shortfall'.

Modelling of a system (i.e. healthcare system) is driven by two factors: 1) nature of the system and 2) data availability. Modelling is a methodology that describes the interaction of elements inside the system by an equation or a series of equations, in form of numerical and/or logical equations. For systems that can be physically explained, such as the *locus of a free falling object* and the *period of a swing of a simple gravity pendulum*, the corresponding modelling equations can exactly represent reality. However, for the system that cannot be easily explained by physical phenomena, curve fitting (although confounded by interactions between elements/variables) is a common approach. The historical data sample size necessary for obtaining an accurate curve is exponentially proportion to the number of variables included in the model. Although modelling by a full spectrum of variables can truly reflect the nature of the interaction(s), a full spectrum of variables requires a very large data set to derive the best estimate of the interaction(s). Therefore, modelling of uneasily explained systems must accommodate a trade-off between the number of variables and the size of the available data sets. The selection of representative and available variable(s) and the fitting of a numerical expression (model) to these variables is a key issue of system modelling. Examples of commonly used numerical expressions include linear, quadric, exponential, and neural network models. System

modelling involves two sets of approximation: approximate full variable spectrum by a limited number of variables and approximate the interactions amongst the variables by (numerical and/or logical) expression(s), to which the modelled system is an approximation of the real system.

Hong Kong healthcare manpower is an extremely complicated system which cannot be easily described by physical phenomena. Therefore, we adopt the 'curve fitting of historical sample' approach to model manpower. The core assumption of this model (an essential and common assumption of system models) is that the manpower projection follows historical trends in the data.

2 Projecting doctor demand

2.1 Demand indicators

Parameters for demand model projections

For the public sector, all HA age-, sex-specific in-patient discharge records (2004 to 2011; including day case, A&E, acute care in-patient and long stay) and all age-, sex-specific outpatient visits (for general and specialist outpatients, 2005-2011) and DH service attendances (2005-2011) are available for the healthcare utilisation projections. Data from 2005 are used for the public sector model, as the data prior to these years would have been unduly influenced by organisational change within the HA and by the SARS epidemic. Table A1 and Table A2 in Annex 1 specifies the variables, parameterisation and data sources. Attendances for DH clinical service units are age-, sex-specific and grouped by service type.

For the private sector, private hospital age-, sex-specific in-patient discharge records (2007-2011: including day case and acute care in-patient) are used as utilisation trends and data available prior to 2007 were of inconsistent quality. Age-, sex-specific outpatients visits from the THS 2005, 2008, 2009 and 2011 are used for the private sector outpatient utilisation projections with adjustment for underreporting.

Discharge rates (day case, acute care, long stay) - The discharge rates are based on HA (2005-2011) and private hospital in-patient (2007-2011) discharge records. All age-, sex-specific in-patient (day case (LOS ≤1 day), acute care (LOS > 1 day excluding long stay episodes) and long stay (those designated officially as such) discharges are included.

Outpatient visit rates - HA A&E, general and specialist outpatient visit records per year (2005-2011) and DH service unit attendances (2005-2011) are used to project age-, sex-specific public sector outpatient visit rates. Due to the limited number of data points for private sector outpatient visits (THS data for 2005, 2008, 2009 and 2011) outpatient visit rates for 2006, 2007, and 2010 are estimated using the observed public (HA, excluding A&E and DH) : private outpatient visit proportion as follows:

$$n_{private}^{outpatient}(a,s,y) = n_{HA}^{GOP}(a,s,y) \times \alpha_{OP}(a,s,THS(y))$$

Eq. 1

where

$n_{private}^{outpatient}(a,s,y)$ is the number of private outpatient visits of age-sex group (a,s) at year y

$n_{HA}^{GOP}(a,s,y)$ is the number of HA-based outpatient visits of age-sex group (a,s) at year y

$\alpha_{OP}(a,s,THS(y))$ is the ratio of private to HA-based outpatient visits of age-sex group (a,s) at the year $THS(y)$

The ratio of private to public outpatient visits for years 2006, 2007, and 2010 (for which no THS was available) are estimated by interpolating from the ratios estimated from THS 2005, 2008, 2009, and 2011. Only HA outpatient visits are included as DH service attendances are seriously under-reported in the THS data. Private sector outpatient visits include solo practice clinics (single practitioner), group practice clinics (multiple practitioners of single or multiple specialties), private hospital outpatient clinics, institutional clinics (charitable organization and 'exempted' clinics), university/tertiary institution clinics and Family Planning Association of Hong Kong clinics.

Although the total number of attendances at the DH clinical service units is available per year (2005-2011), age-, sex-specific visit data are not available for all clinics or for all years. For some services, the age-, sex-specific distribution is interpolated from the distribution of a related service, or estimated from a sample. For example, the age-, sex-specific distribution of Elderly Health Service (EHS) attendances for medical consultations is derived from the distribution of Elderly Health Service attendances

for health assessment. For other services, attendance records are available for a limited number of years. The missing data are interpolated from the age-, sex-specific distribution in the nearest year for which data are available assuming no change in attendance patterns.

Total bed-days (acute care and long stay patients) - Average length of stay (ALOS) (total bed-days by age-, sex-specific discharges) is separately calculated for public acute care in-patients and long stay patients, and private acute care in-patients. Age-, sex-specific ALOS for acute care in-patients (length of stay (LOS) > 1 day, excluding long stay[1] episodes) is determined from HA in-patient discharge records (2005-2011) and private hospital in-patient discharge records (2007-2011). Age-, sex-specific ALOS for long stay in-patients (those designated officially as long stay[3] episodes) is determined from HA in-patient discharge records (2005-2011).

2.2 Converting healthcare utilisation to full time equivalents (FTEs)

Two regression-based approaches are used to convert healthcare demand/utilisation to doctor FTEs by service sector (public and private) and by service type (in-patient vs. outpatient, specialist vs. general practitioner).

Hospital Authority

FTE is expressed as a linear combination of utilisation measures:

$$FTE_{HA}^{inpatient}(y) = \left(d_{HA}^{daycase}(y) + d_{HA}^{inpatient}(y) + d_{HA}^{longstay}(y)\right) \times c_{discharge} + \left(b_{HA}^{inpatient}(y) - 2d_{HA}^{daycase}(y)\right) \times c_{inpatient}^{bedday} + \left(b_{HA}^{longstay}(y) - 2d_{HA}^{longstay}(y)\right) \times c_{longstay}^{bedday}$$

Eq. 2

$$FTE_{HA}(y) = FTE_{HA}^{inpatient}(y) + n_{HA}^{SOP}(y) \times c_{HA}^{SOP} + n_{HA}^{GOP}(y) \times c_{HA}^{GOP} + n_{A\&E}(y) \times c_{A\&E}$$

Eq. 3

[1] *Long stay episodes fulfil one of the following criteria: discharge specialty denoted by HA as either "infirmary", "mentally handicapped", or "psychiatry AND total length of stay >90 days*

The workload coefficients $\{c_{discharge}, c_{inpatient}^{bedday}, c_{longstay}^{bedday}, c_{HA}^{SOP}\}$ are estimated by minimizing the sum of difference between the estimated FTE in Eq. 2 and the actual FTE:

$$\begin{aligned}[c_{discharge}, c_{inpatient}^{bedday}, c_{longstay}^{bedday}, c_{HA}^{SOP}] \\ = arg \min_{[p,q,r,z]} \sum_{y} \Big(\Big(d_{HA}^{daycase}(y) + d_{HA}^{inpatient}(y) + d_{HA}^{longstay}(y) \Big) \times p \\ + \Big(b_{HA}^{inpatient}(y) - 2d_{HA}^{inpatient}(y) \Big) \times q \\ + \Big(b_{HA}^{longstay}(y) - 2d_{HA}^{longstay}(y) \Big) r + n_{HA}^{SOP}(y) \times z - D_{HA}^{inpatient}(y) \\ - D_{HA}^{SOP}(y) \Big)^2 \end{aligned}$$

Eq. 4

where $D_{HA}^{inpatient}(y)$ is the number of FTE doctors in HA inpatient setting at year *y*, and $D_{HA}^{SOP}(y)$ is the number of FTE doctors in HA SOPD at year *y*.

The workload coefficient of HA GOP visit c_{HA}^{GOP} is estimated as average FTE doctor-to-HA GOP visit ratio:

$$c_{HA}^{GOP} = \frac{1}{7} \sum_{y=2005}^{2011} \frac{D_{HA}^{GOP}(y)}{n_{HA}^{GOP}(y)}$$

Eq. 5

where $D_{HA}^{GOP}(y)$ is the number of FTE doctors in HA GOPD at year *y*

The workload coefficient of HA A&E attendance $c_{HA}^{A\&E}$ is estimated as average FTE doctor-to-A&E attendance ratio:

$$c_{HA}^{A\&E} = \frac{1}{7} \sum_{y=2005}^{2011} \frac{D_{HA}^{A\&E}(y)}{n_{HA}^{A\&E}(y)}$$

Eq. 6

where $D_{HA}^{A\&E}(y)$ is the number of FTE doctors in HA A&E department at year *y*

Based on the coefficients the corresponding $\alpha_{workload} = \frac{workload\ on\ inpatient\ care}{workload\ of\ specialist}$ is 0.6. This is consistent with the number of GOP consultations reported in the DH HMS for Doctors (2004-2007 and 2009) and estimates from the HA historical outpatient visit data.

Department of Health

As historical data for the number of DH doctors by service type is not available the DH doctor FTE conversion is calculated as follows:

DH clinic visit workload (except for the Methadone clinics) is assumed to be the same as a HA general outpatient visit. The utilisation of all clinics excluding the Methadone clinics was used to calculate FTE's. Each Methadone clinic (20) is assumed to have one doctor. FTE's are expressed as a linear combination of these utilisation measures:

$$FTE_{DH}(y) = c_{HA}^{GOP} \sum_{i \neq 4} n_{DH}^{i}(y) + 20$$

Eq. 7

Private sector

Although similar methods are used for the private sector doctor FTE conversion, additional parameters are included such as:- the per hospital proportion of resident and visiting doctors, and the proportion of clinic-based non-visiting doctors.

FTE is expressed as a linear combination of utilisation measures:

$$\begin{aligned} FTE_{private}^{inpatient}(y) & \\ &= d_{private}^{daycase}(y) \times w_{daycase}^{discharge} + d_{private}^{inpatient}(y) \times w_{inpatient}^{discharge} \\ &+ \left(b_{private}^{inpatient}(y) - 2d_{private}^{inpatient}(y)\right) \times w_{inpatient}^{bedday} \end{aligned}$$

Eq. 8

and

$$FTE_{private}(y) = FTE_{private}^{inpatient}(y) + n_{private}^{outpatient}(y) \times w_{private}^{outpatient}$$

Eq. 9

The workload coefficients $\{w_{daycase}^{discharge}, w_{inpatient}^{discharge}, w_{inpatient}^{bedday}\}$ are estimated by minimizing the sum of difference between the estimated FTE in Eq. 8 and the actual FTE:

$$[w_{daycase}^{discharge}, w_{inpatient}^{discharge}, w_{inpatient}^{bedday}] = arg \min_{[p,q,r]} \sum_{y} \Big(d_{private}^{daycase}(y) \times p + d_{private}^{inpatient}(y) \times q + \Big(b_{private}^{inpatient}(y) - 2d_{private}^{inpatient}(y) \Big) \times r - D_{private}^{inpatient}(y) \Big)^2$$

Eq. 10

where $D_{private}^{inpatient}(y)$ is the number of FTE doctors in private hospital inpatient setting at year y.

The workload coefficient of private outpatient visit $c_{private}^{outpatient}$ is estimated as average FTE doctor-to-private outpatient visit ratio:

$$w_{private}^{outpatient} = \frac{1}{7} \sum_{y=2005}^{2011} \frac{D_{private}^{outpatient}(y)}{n_{private}^{outpatient}(y)}$$

Eq. 11

where $D_{private}^{outpatient}(y)$ is the number of FTE doctors in private outpatient clinic at year y

Suppose $D_{private}(y)$is denoted as the number of FTE doctors in the private sector at year y; α_r is the proportion of resident doctor, α_v is the proportion of visiting doctor, α_c is the proportion of clinic-based non-visiting doctor (i.e. $\alpha_r + \alpha_v + \alpha_c = 1$), β is the 'in-patient-outpatient workload' proportion of resident doctor, and λ 'in-patient-outpatient workload' proportion of visiting doctor.

The number of FTE doctors in private hospital inpatient setting $D_{private}^{inpatient}(y)$ is expressed as:

$$D_{private}^{inpatient}(y) = (\alpha_r \beta + \alpha_v \lambda) \times D_{private}(y)$$

Eq. 12

and the number of FTE doctors in private outpatient clinic is expressed as:

$$D_{private}^{outpatient}(y) = (\alpha_r(1-\beta) + \alpha_v(1-\lambda)) \times D_{private}(y)$$

Eq. 13

The value of coefficients α_r, α_v, and α_c are based on the *Private Doctor Survey 2012* conducted by School of Public Health, The University of Hong Kong; β follows the 'in-patient-outpatient workload' proportion of public sector. For λ, the daily activity of a visiting doctor is assumed to be: 10:00 am – 1:00 pm and 3:00 pm – 6:30 pm in clinic, and 2 hours in hospital.

The average number of private outpatient consultations per FTE doctor per day derived from the THS 2009 (data corrected for under-reporting) is used to calculate FTE doctors needed for the projected private outpatient visits from 2012-2041. A linear regression model is used to convert in-patient workload (day case, in-patient discharges, and bed-days) to FTE doctors.

The demand FTEs, $FTE_{demand}(y)$, at year y is calculated as:

$$FTE_{demand}(y) = FTE_{HA}(y) + FTE_{DH}(y) + FTE_{private}(y)$$

Eq. 14

2.3 Modelling doctor demand

After a thorough literature review, assessing the suitability to the local context and exploratory analyses with the various possible projection modes, three approaches for projecting healthcare utilisation are shortlisted for further consideration, the 'empirically observed historical' (EOH), the 'macroeconomic scenario driven' (MSD) and the 'Andersen-type' (Andersen) approach within a 'top down' and 'bottom up' framework (Figure 2.1). Given the lack of required data elements for the Andersen approach, namely detailed individual-level data on predisposing and enabling factors as well as panel studies locally, the two 'top down' approaches are eventually executed.

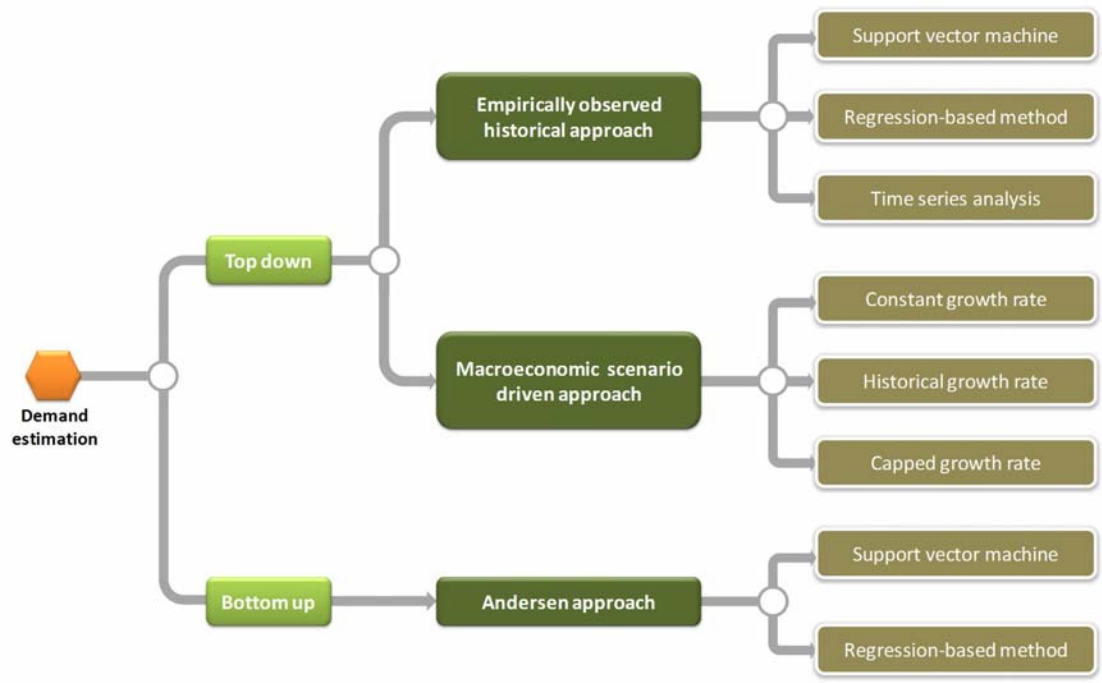

Figure 2.1 Approaches to estimating doctor demand

Support vector machine (neural network analysis), regression-based method, and stock and flow method, are variously deployed to project the required number of doctors as a function of healthcare demand/utilisation and doctor supply to 2041. The projections are stratified by service type (in-patient and outpatient) and by service location (public or private sector).

Empirically observed historical (EOH) approach

The EOH projection model expresses utilisation z(y) at year y as the product of population P and utilisation rate R:

$$z(y) = \sum_{a} \sum_{s} P(a,s,y) \times R(a,y|s)$$

Eq. 15

where $P(a,s,y)$ is the population age-, sex-specific groups (a,s) at year y, and $R(a, y \mid s)$ is the utilisation rate by age-, sex-specific groups (a,s) at year y. Census and Statistics Department population projections are used for the projected $P(a,s,y)$, historical data inform the computation of $R(a, y \mid s)$.

1. Support vector machine (SVM)

SVM[2] is used to estimate the utilisation rate of each age-, sex-specific group at a given year. SVM is a kernel-based neural network that maps an input x to an output y where w_i is the weight and B is the bias term by the following expression:

$$y = \sum_i w_i \kappa(\mathbf{x}_i, \mathbf{x}) + B$$

Eq. 16

As compared with linear and exponential regression models, SVM has the flexibility to 'evolve' an optimal structure according to historical data. A Gaussian radial basis kernel i.e. $\kappa(\mathbf{x}, \mathbf{y}) = \exp(C\|\mathbf{x} - \mathbf{y}\|)$ is used as it is the 'universal approximator'. The structure is well regularised, and the generalisation ability of the network is maximized.

SVM *learn* the utilisation rate pattern from historical data expressed as:

$$\begin{bmatrix} a_1, s_1, y_1 | r_1 \\ a_2, s_2, y_2 | r_2 \\ a_3, s_3, y_3 | r_3 \\ \vdots \end{bmatrix}$$

where r_i is the utilisation rate of age-, sex-specific group (a_i, s_i) at year y_i. A specific network construction algorithm is designed to evolve the structural parameters $\{w_i\}$ and B. The trained SVM projects the utilisation rate $R(a,s,y)$ of an age-, sex-specific group (a, s) at projection year y = 2012, 2013, …. using the following equation:

$$R(a, y|s) = \sum_{i\ for\ all\ s_i = s} w_i e^{-\frac{(a-a_i)^2 + (y-y_i)^2}{2\sigma^2}} + B$$

Eq. 17

The utilisation volume at year y is computed as:

$$\sum_a \sum_s R(a, y|s) \times P(a, s, y)$$

Eq. 18

where $P(a,s,y)$ is the population size of the age-sex group (a,s) at year y.

[2] Artificial neural networks (ANN) and specifically the Support Vector Machine (SVM) used for these projections are able to predict the complex relationships driving utilisation. Support vector machine (SVM) is a supervised learning method that analyses data and recognizes data patterns in the historical data. As such this artificial intelligence predicts for each given variable the corresponding outcome. SVM was chosen for the projection as it will 'evolve' an optimal structure and estimate the service utilisation of a given individual based on characteristics such as age, and sex.

2. Regression-based method (RBM)

In the RBM approach, $R(a,s,y)$ is estimated by Poisson regression, which assumes:

$$N(a,s,y) \sim Poisson(O(a,s,y)R(a,s,y))$$
$$\log R(a,s,y) = \alpha(a,s) + \beta(a,s)y$$

Eq. 19

where $N(a,s,y)$ denotes the utilisation volume and $O(a,s,y)$ is an offset term in age group a, sex s, and year y. For the projection of all utilisation measures except average length of stay, the population of age group a, sex s, and year y are used for the offset term $O(a,s,y)$. For the projection of average length of stay, the offset term is the number of discharges. Since $\log R(a,s,y)$ is a linear function of y, $R(a,s,y)$ is an exponential function of y all age- and sex-specific demand variables are included in the Poisson regression. For utilisation measures where there are clear differences in slopes across age-, sex-specific groups (including public and private day case, acute care in-patient discharge and average length of stay (ALOS), as well as HA general outpatient (GOP), specialist outpatient (SOP), accident and emergency (A&E), and private outpatient visits), the projections have age-, sex-specific intercepts and slopes. For all other utilisation measures (public long stay discharge and average length of stay, as well as all DH service visits), the age-, sex-specific intercepts and slopes are constrained to be the same across age and sex groups.

In sensitivity analyses, the Poisson regression projections are compared with projections based on a linear trend. As utilisation rates in linear trend projections may drop below 0, linear projections are used only for utilisation rates that show an increasing trend. The utilisation rate increase is assumed to be the same across all age-, sex-specific groups for SOP, A&E, private outpatient, and all DH visit rates projections lest projections for individual age and sex groups reach zero.

A weighted linear regression is deployed, where the population in age group a, sex s, and year y are used as weights (i.e., $P(a,s,y)$). The following function is minimised with respect to $\alpha(a,s)$ and $\beta(a,s)$.

$$\sum_{a}\sum_{y}\sum_{s} P(a,s,y)(R(a,s,y|s) - \alpha(a,s) - \beta(a,s)y)^2$$

Eq. 20

Projections of rates are given as:

$$\hat{R}(a,s,y) = \alpha(a,s) + \beta(a,s)y$$

Eq. 21

The weights are needed to ensure the estimated age, sex, and year-specific rates $\hat{R}(a,s,y)$ are consistent with the observed rates $R(a,s,y)$.

3. Time series approach

As the elderly and rehabilitation service provision is land-driven, a time-series analysis is used to project the historical growth patterns for elderly and rehabilitation services assuming growth trends *u*(*y*) as follow:-

Linear trend

Where the number of places / cases is a linear function of projection year *y*:

$$u(y) = ay + b$$

Eq. 22

Exponential decay trend

Where the number of applications is expected to decrease exponentially:

$$u(y) = we^{-\alpha y} + c$$

Eq. 23

Constant trend

Where service provision is stable and held constant as at the baseline year:

$$u(y) = u_0$$

Eq. 24

Macroeconomic scenario drive (MSD) approach

As in the EOH-RBM approach, the MSD approach expresses utilisation *z*(*y*) at year *y* as the product of population *P* and utilisation rate *R*:

$$z(y) = \sum_{a}\sum_{s} P(a,s,y) \times R(a,s,y)$$

Eq. 25

where $P(a,s,y)$ is the age-, sex-specific population (a,s) at year y, and $R(a,s,y)$ is the age-, sex-specific utilisation rate (a,s) at year y. Based on a fixed percentage increase from 2011 levels, population projections of the Census and Statistics Department are used to project $P(a,s,y)$. $R(a,s,y)$ is estimated as follows:-

$$R(a,s,y) = R(a,s,2011) \times (1+x)^{y-2011}$$

Eq. 26

Three methods (constant growth, historical growth, and capped growth) are used to calibrate healthcare utilisation trends against observed data.

4. Constant growth rate

The constant growth rate method sets 'excess healthcare price/cost inflation'[3] growth at 0.2% public sector and 1% for the private sector, consistent with the international literature and to a previous local exercise [1]. The public sector growth rate for each variable is benchmarked to the OECD (1999) [3]. As the OECD reports utilisation growth rates of 0.4% per year, the model assumes a growth rate of 0.2% [4] because half of the growth is due to the net growth in the utilisation rate while the other half is assumed to be due to demographic changes.

Private sector growth rates are benchmarked to OECD (1999) [3] data for the United States and Switzerland, as these two countries predominantly provide healthcare in the private, albeit regulated, sector. The OECD reports an annual growth of 2.7% and 2.4% for the United States and Switzerland respectively. As the healthcare in Hong Kong is equally shared between the public and private sector, the utilisation growth rate in the private sector is assumed to be 1% [4].

[3] The 'excess healthcare price/cost inflation' method is based on the United Kingdom Treasury's Wanless projection method which requires health expenditure to be broken down by age, sex, unit cost and activity level (i.e. volume in terms of healthcare utilisation). The projections take into account aspects of medical inflation (that is medical inflation over and above per capita Gross Domestic Product growth), changes in the utilisation of healthcare services as a result of demographic change, and total health care expenditure (activity levels multiplied by projected unit costs). This comprises two components medical price increase and per capita volume growth according to Huber's review of health expenditure among OECD countries in 1999.

5. Historical growth rate

For the historical growth rate method, 'excess healthcare price/cost inflation' x is estimated from the public and private hospital in-patient discharges and outpatient visits in Hong Kong.

To estimate x, the following function is minimised:

$$\sum_{y} |N(y) - z(y)|$$

Eq. 27

where $N(y)$ is the utilisation volume (number of public and private sector in-patient discharge rates and outpatient visits) and $z(y)$ is the estimated utilisation volume for that year:

$$z(y) = \sum_{a}\sum_{s} P(a,s,y) \times R(a,y|s)$$

$$R(a,s,y) = R(a,s,2011) \times (1+x)^{y-2011}$$

Eq. 28

6. Capped growth rate

As it may be inappropriate to assume ever exponentially increasing utilisation rates, the capped growth rate method is applied to the projection of discharge rates and outpatient (SOP and GOP) visit rates, such that rates would not indefinitely grow exponentially as follows:

$$R(a,s,y) = R(a,s,2011) \times \left(\frac{w}{1+e^{-\alpha(y-y_0-\mu)}} + B\right)$$

Eq. 29

where $R(a,s,2011)$ is the age-, sex-specific utilisation rate for the baseline year 2011, and $\frac{w}{1+e^{-\alpha(y-y_0-\mu)}} + B$ is the general expression of *sigmoid function*

For average length of stay projections, a biased exponential function is used.

$$ALOS(a,s,y) = ALOS(a,s,2011) \times e^{-\alpha(y-\mu)} + B$$

Eq. 30

where $e^{-\alpha(y-\mu)}$ is the general expression of *biased exponential function*.

The parameters w, α, μ and B are estimated by optimising the objective function:

$$\sum_{y} |N(y) - z(y)|$$

Eq. 31

as in the historical growth rate model.

Adjusting for under-reporting

THS under-reporting rates for outpatient visits for the public and private sector are estimated for the THS 2002, 2005, 2008, and using routine HA and private hospital outpatient visits data (Figure 2.2). Due to data unavailability, estimates of under-reporting rates for private sector outpatient visits is not possible. Private sector under-reporting rates are assumed to be the same as for HA outpatient visits.

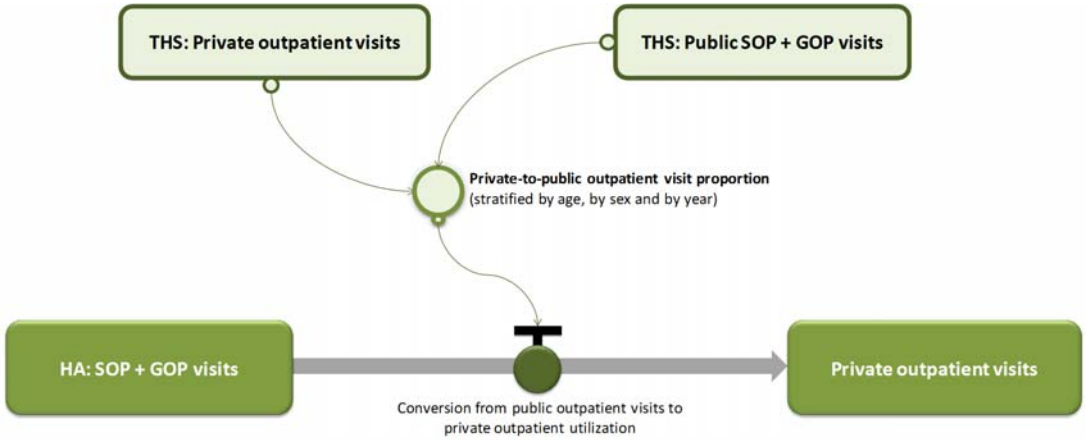

Figure 2.2 Under-reporting adjustment of THS outpatient visit data

Capping rates

The RBM gives exponential rate increases across all utilisation variables. This leads to projections that are too extreme to be realistic beyond the first few years. To address this problem, age-, sex-specific utilisation rates are allowed to continue until 2016 after which they are held constant (i.e. capped) for the rest of the projection period. The discharge and outpatient visit rate caps are benchmarked to the historical OECD utilisation trend data (OECD 2012) [3].

To set the discharge rate cap, the current OECD acute care in-patient discharge rate for Hong Kong (178 discharges/1000 person-year [2]) is compared to OECD individual country trends (Figure 2.3). Hong Kong discharge rate increase is benchmarked to the 90th percentile of the 2011 OECD countries discharge rate (237 discharges/1000 person-year) (representing an average discharge rate increase of 33%). Based on historical data Hong Kong will reach this estimated discharge rate by 2016, after which the discharge rate increase is capped.

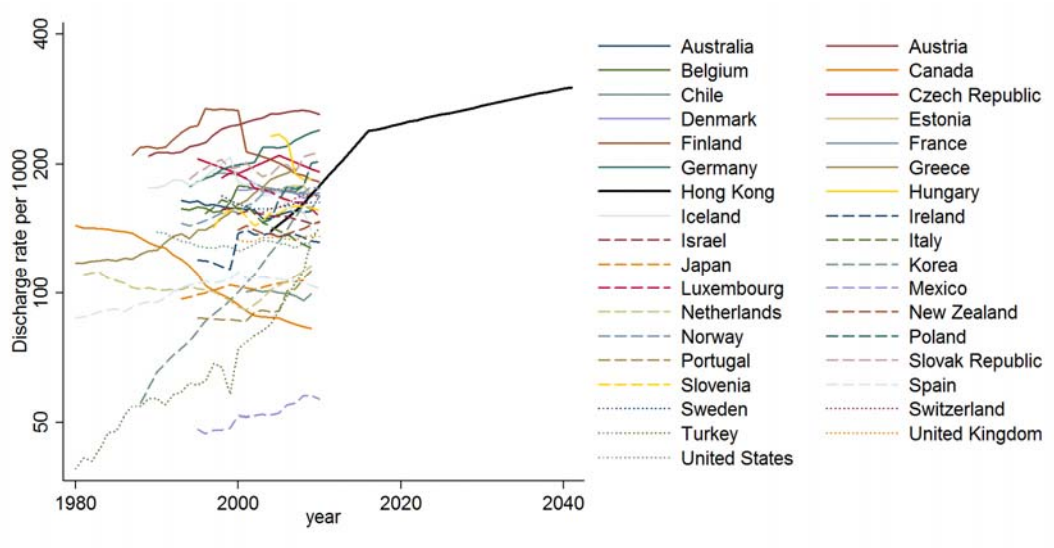

Figure 2.3 Comparison of Hong Kong and OECD acute care in-patient hospital discharge rates (152,153)

Similarly for outpatient visit rates, the doctor visit rate as published by the OECD for HK (2011) (11.2 visits per person-year [2]) is benchmarked against OECD individual country trends (highest rate 13.1 visits per person per year in Japan) (Figure 2.4). Based on this comparison, Hong Kong outpatient visit rates are expected to increase by 17% and will reach this target by 2016. The outpatient visit rate is capped after 2016.

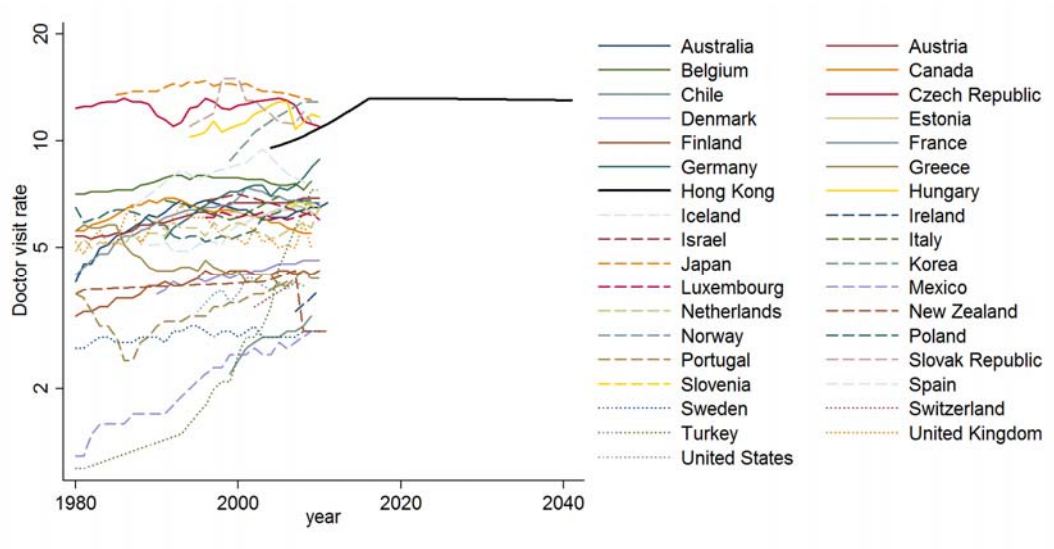

Figure 2.4 Comparison of Hong Kong and OECD doctor outpatient visit rates [2] [3]

2.4 Model comparison

The top down methods (EOH and MSD), with relatively fewer data requirements, are based on the expectation that simple, aggregate models provide more reliable and reproducible healthcare utilisation projections. Further consistent, comprehensive data (number of observations and data-points) are available for the public sector. Much less reliable data are available for the private sector.

The performance of a model is represented by the sum of absolute rate error $E(\theta, u)$:

$$E(\theta,u) = \sum_{a}\sum_{y}\sum_{s}\left|\widetilde{M_u}(a,s,y|\theta) - R_u(a,s,y)\right|$$

Eq. 32

where $E(\theta, u)$ is the sum of absolute rate error of model θ ∈ {EOH-SVM, MSD-constant growth rate, MSD-historical growth rate} on utilisation u

$\widetilde{M_u}(a,s,y|\theta)$ is the estimated utilisation rate on u of age-sex group (a, s) at year y by model θ and

$R_u(a,s,y)$ is the actual utilisation rate on u of age-sex group (a, s) at year y.

Note that the index y in the formulate of $E(\theta, u)$ has different range for different utilisation measures: $y \in$ {2005, 2006, …, 2011} for public sector and private

outpatient utilisation; and $y \in \{2007, 2008, \ldots, 2011\}$ for private sector inpatient utilisation. Table 3.3 lists the estimation error of EOH-SVM, MSD-constant growth rate and MSD-historical growth rate. The EOH-SVM models give a better model fit than the MSD models (Table 2.1). The EOH-SVM estimation errors are smaller than those for the MSD-constant growth or MSD-historical growth rate models.

Table 2.1 Comparison of EOH-SVM, MSD-constant growth, MSD-historical growth rate estimation errors

	EOH-SVM	**MSD (constant growth rate)**	**MSD (historical growth rate)**
Day case discharge rate (public)	0.93	7.56	1.53
Acute care in-patient discharge rate (public)	0.82	3.83	2.05
Acute care in-patient bed day rate (public)	7.29	44.65	17.19
Long stay discharge rate (public)	0.03	0.08	0.05
Long stay bed day rate (public)	11.09	28.42	20.21
SOP visit rate	3.67	8.09	8.08
GOP visit rate	4.04	16.95	10.06
A&E attendance rate	2.26	5.30	4.69
Day case discharge rate (private)	0.18	0.57	0.48
Acute care in-patient discharge rate (private)	0.11	0.42	0.33
Acute care in-patient bed day rate (private)	1.06	2.45	2.28
Private outpatient rate	99.03	252.69	251.94

In a sensitivity analysis, as would be expected, the EOH-RBM linear based model gives projections that are less steep than the Poisson model (which assumes an exponential trend) however, the data do not support a linear trend more than an exponential trend. The mean squared error is smaller for most utilisation measures projected by the RBM-Poisson model (

Table 2.2). To avoid negative values, age-, sex-specific utilisation measures in the RBM linear model, share the same intercepts and slopes.

Table 2.2 Comparison of the linear and exponential RBM utilisation projections mean squared error (MSE) for selected demand/utilisation variables.

Demand/utilisation variables	**Natural scale**		**Log scale**	
	Linear	*Exponential*	*Linear*	*Exponential*
Public day cases	25.8	**18.0**	0.0038	**0.0026**
Public specialist outpatient visits	700	**522**	0.0014	**0.0007**
Public general outpatient visits	1189	**830**	0.0038	**0.0017**
Accident and Emergency visits	165.4	**125.8**	0.0021	**0.0016**
Private day cases	**1.63**	1.76	**0.0029**	0.003
Private acute care in-patient discharges	**6.13**	6.69	0.0028	**0.0013**
Private outpatient visits	771405	**561993**	0.032	**0.026**
DH Student and child services	1022	**982**	1.21	**0.09**
DH Port Health Office	0.20	**0.18**	0.18	**0.05**

SVM models have the ability to generalize, learn from examples, adapt to situations based on historical data and generalize patterns from historical data in response to unknown situations. SVM implicitly detects complex nonlinear relationships between independent and dependent variables. When responding to nonlinearity between the predictor variables and the corresponding outcomes, the model automatically adjusts its structure to reflect these nonlinearities. The predictor variables in SVM undergo multiple nonlinear transformations and can thereby potentially model much more complex nonlinear relationships than RBM.

Regression models can also be used to model complex nonlinear relationships. However, these models require an explicit search for these relationships by the model developer and these may not be known or well understood. Appropriate transformations may not always be available for improving model fit, and significant nonlinear relationships may go unrecognized by model developers.

When complex data and relationships are involved, as compared to RBM, SVM would in theory at least, and empirically shown by the model fit statistics above, provide a more robust projection outcome, more flexibly integrates complex data into the model, and is not dependent on a pre-determined hypotheses about the relationships between model variables. For these reasons, the EOH-SVM approach has been used for all model projections in the report.

3 Projecting doctor supply

Hong Kong Medical Council doctor registration data (age-, sex-specific) for 2012 [5] –[6] is used for the doctor supply base case. The University Grants Committee data for past and projected number of local medical student graduates and data from the DH Healthcare Manpower Survey (HMS) [7] - [11] for Doctors (with the public sector proportion adjusted to be consistent with the actual by the HA doctor employment records [Statistical Report [12] from 2005 – 2007, 2009) are used for the supply projections.

3.1 Models for doctor supply

The doctor supply model is a non-homogenous Markov Chain Model (MCM)[4], where workforce systems are represented as "stocks and flows" (Figure 3.1). Flow refers to manpower supply over a period of time. Stock denotes manpower supply at a particular point in time.

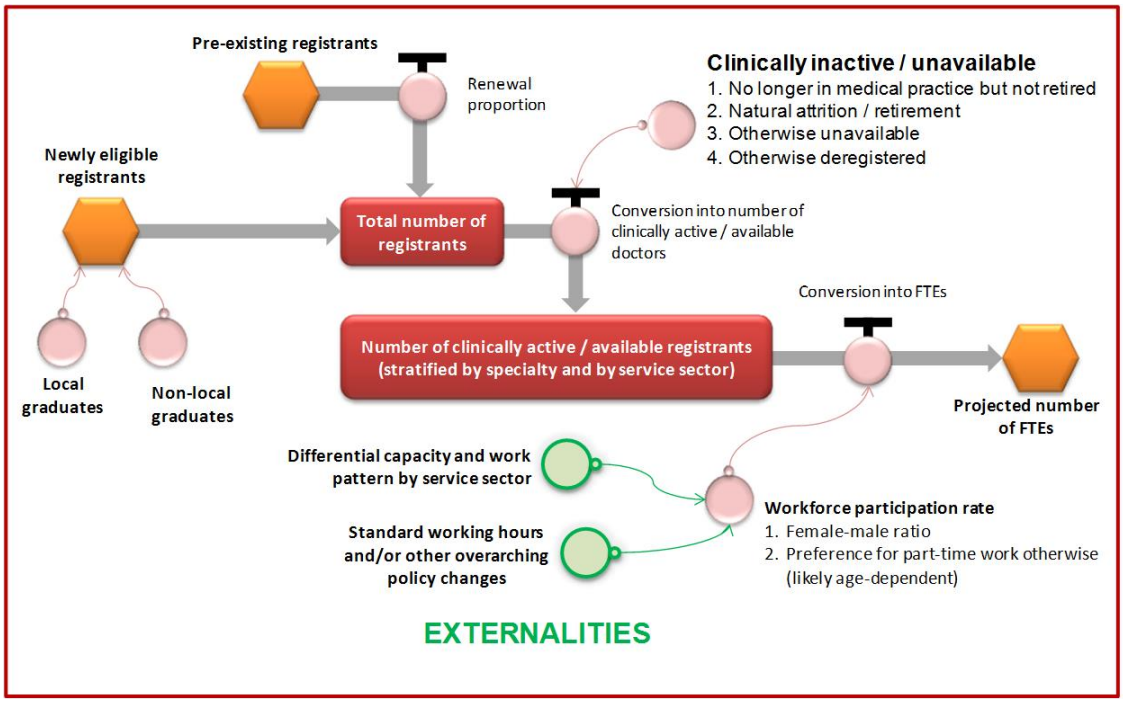

Figure 3.1 Doctor supply model for Hong Kong.

[4]Markov Chain Model (MCM): MCM estimates transition probabilities relevant to manpower stock and flow and is useful for micro level manpower planning

There are five age-sex specific stocks by year (a,s,y) in the model:

n_{pre}	number of pre-existing registrants
n_{local}	number of local graduates
$n_{non\text{-}local}$	number of non-local graduates
$n_{current}$	number of current registrants
n_{active}	number of active and available registrants

Flow in the supply model represents change in the stocks and is projected by determining:

The number of current registrants (total number of local graduates, non-local graduates and pre-existing registrants):

$$n_{current}(a,y,s) = p_{renewal} \times n_{pre}(a,y,s) + n_{local}(a,y,s) + n_{non-local}(a,y,s)$$

and

$$n_{pre}(a,y,s) = n_{current}(a,y-1,s)$$

Eq. 33

where $p_{renewal}$ is the licence renewal proportion.

The number of active and available registrants:

$$n_{active}(a,y,s) = n_{current}(a,y,s) \times p_{active}(a,s)$$

Eq. 34

where $p_{active}(a,s)$ is the active proportion of age-sex group (a,s).

3.2 Determinants of supply: projecting stock and flow

Total number of registrants

The total number of registrants is defined as the number of pre-existing registrants (pool of registered doctors multiplied by the registration renewal proportion [as provided by the HKMC]) and the newly eligible registrants (new medical graduates

from the University of Hong Kong (HKU) and the Chinese University of Hong Kong (CUHK), new provisional licences [for medical interns]) and non-local graduates entering the pool by year (2005-2011).

Based on the number of medical student placements (set by the UGC) and the expected number of provisional licences for medical interns, the number of new registrants are projected using a sigmoid function. The supply model thus assumes a cap on medical student graduation at 420 students from 2019 – 2041. Although data are available for the HKMC (2001-2011) (155,156) licensing examination pass rates, based on the current (2012) number of non-local registrants, the supply model assumes a constant inflow of 60 non-local graduates to the registration pool per year, that is in line with the latest year statistics.

Number of clinically active registrants

Although the total number of registrants adds to the total doctor pool, it is the number of clinically active/available[5] registrants that is relevant for workforce projection. The supply model stratifies clinically inactive/unavailable doctors into four categories: no longer in medical practice but not retired, natural attrition/retirement, otherwise unavailable, and otherwise deregistered. Based on the HMS on Doctors [7] - [11], a sigmoid function is used to project the number of doctors who are no longer in medical practice but not retired, doctors who leave due to natural attrition/retirement, and those otherwise unavailable. Based on HKMC data [5] [6], one doctor is assumed deregistered each year.

3.3 Converting workforce supply to full time equivalents (FTEs)

The model uses the age-, sex-specific stratified average working hours to determine the total hours worked by sector. The average working hours in any sector is capped at 65 hours per week (equivalent to 1 FTE).

[5] The definition for clinically active/available doctors varies from that adopted by the DH. We have excluded doctors who are no longer in medical practice but not retired, those otherwise unavailable from the clinically active and available, and those deregistered.

The supply FTEs, $FTE_{supply}(y)$, at year y is calculated as:

$$FTE_{supply}(y) = \frac{\sum_a \sum_s (n_{active}(a,y,s) \times \sum_c p_{sector}(a,s,c) \times h(a,s,c))}{Standard\ working\ hours\ per\ week\ per\ FTE}$$

Eq. 35

where $p_{sector}(a,s,c)$ is the proportion of doctors working in the service sector c at year y, and $h(a,s,c)$ is the average number of working hours per doctor.

The supply projection is based on the stocks and also the parameters $p_{renewal}$, $p_{active}(a,s)$, $p_{sector}(a,s,c)$ and $h(a,s,c)$. A sigmoid model is used to project the parameters.

4 Gap analysis

The gap analysis quantifies the difference between the projected demand for and supply of doctors for the base case (assumed demand and supply is at equilibrium from 2005 – 2011, i.e. realised demand equals realised supply where the gap is defined to be zero).

For the supply base case, the projected FTE supply includes only those working in the HA, the private sector, and the DH. As the data available do not separately report DH headcount, the model assumes that 30% of the 'Government, academic, and subvented' headcount are attributable to the DH. Others in the 'Government, academic, and subvented' category are not included in the gap analysis supply projections.

The gap analysis used a top down approach for FTE conversion, based on empirical data and using regression-based methods determined an in-patient-outpatient workload proportion of 0.6.

Three methods (annual number of FTEs, year-on-year FTE, and annual incremental FTE) are used to quantify FTE doctor demand and compared to the base case supply projections.

Annual number of FTE

The number of FTE doctors in year *y* is stratified into the number of FTE demand doctors and the number of FTE supply doctors. Their expressions are shown in in Eq. 14 and Eq. 35 respectively

Year-on-year FTE

The year-on-year FTE method quantifies the accumulated difference between demand and supply as follows:-

$$a(y) = FTE_{demand}(y) - FTE_{supply}(y)$$

Eq. 36

where $a(y)$ is the year-on-year FTE at year *y*, FTE_{demand} and FTE_{supply} are the demand and supply FTE at year *y* shown in Eq. 14 and Eq. 35 respectively.

Annual incremental FTE

The annual incremental FTE method quantifies the change in the demand supply gap from the previous year as follow:-

$$I(y) = a(y) - a(y-1)$$

Eq. 37

where $I(y)$ is the annual incremental FTE at year *y*, and $a(y)$ is the year-on-year FTE at year *y* shown in Eq. 36.

5 Assumption

5.1 Demand side

i. We adopt the 'curve fitting of historical sample' approach to model the manpower, the projection is assumed to follow the historical trend in the data.

ii. For the THS private outpatient visits, we assume that the age-sex specific under-reporting rates of private outpatient visit and public general outpatient visit are equal.

iii. The data from five THSs is assumed to be sufficient to represent the historical trend of private outpatient visit.

iv. The data from seven-year HA patient record is assumed to be sufficient to represent the historical trend of HA-based healthcare utilisation pattern.

v. In the estimation of workload coefficients, we assume that demand and supply are balance.

vi. The workload coefficients are assumed to be time-invariant.

5.2 Supply side

i. The number of local graduates from 2019 to 2041 follows that at 2018.

ii. The licence renewal proportion $p_{renewal}$ is assumed to be age-, sex- and time-invariant.

iii. The active proportion $p_{active}(a,s)$ is assumed to be time-invariant.

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April 2014

Annex 1

Table A1 Demand model variables, parameterisation and data sources

Variables		Parameterisation[2]	Data source
Population to be served			
Resident population		Age- sex-stratified	C&SD 1999 through 2011
Population forecast		Age- sex-stratified	C&SD population projections 2012 - 2041
In-patient			
Number of day cases			
Public sector	$d_{HA}^{daycase}$	Age- sex-stratified	HA records 2005-2011
Private sector[1]	$d_{private}^{daycase}$	Age- sex-stratified	Hong Kong private hospitals 2007-2011[1]
Number of acute discharges			
Public sector	$d_{HA}^{inpatient}$	Age- sex-stratified	HA records 2005-2011
Private sector[1]	$d_{private}^{inpatient}$	Age- sex-stratified	Hong Kong private hospitals 2007-2011[1]
Number of long stay discharges			
Public sector	$d_{HA}^{longstay}$	Age- sex-stratified	HA records 2005-2011
Number of acute care bed-days			
Public sector	$b_{HA}^{inpatient}$	Age- sex-stratified	HA records 2005-2011
Private sector[1]	$b_{private}^{inpatient}$	Age- sex-stratified	Hong Kong private hospitals 2007-2011[1]
Number of long stay bed-days			
Public sector	$b_{HA}^{longstay}$	Age- sex-stratified	HA records 2005-2011

Table A2 Demand model variables, parameterisation and data sources

Variables		Parameterisation[2]	Data source
Outpatient			
Number of HA GOP visits	n_{HA}^{GOP}	Age- sex-stratified	HA records 2005-2011
Number of HA SOP visits	n_{HA}^{SOP}	Age- sex-stratified	HA records 2005-2011
Number of HA A&E attendances	$n_{HA}^{A\&E}$	Age- sex-stratified	HA records 2005-2011
DH service unit attendances	n_{DH}^{i}	Age- sex-stratified by service unit $\{i\}$	Department of Health 2005-2011
Number of private outpatient visits	$n_{private}^{outpatient}$	Age- sex-stratified	THS 2005, 2008, 2009, 2011 (Adjusted for under reporting using HA outpatients records 2005-2011)

[1]Private hospitals: Evangel Hospital, Hong Kong Adventist Hospital, Hong Kong Baptist Hospital, Hong Kong Central Hospital, Hong Kong Sanatorium and Hospital, Matilda International Hospital, Precious Blood Hospital, St Paul's Hospital, St Teresa's Hospital, Tsuen Wan Adventist Hospital, Union Hospital, The Canossa Hospital
[2]All data were stratified by age and sex groups in 5-year age categories.

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[11] Department of Health HK. Health manpower survey on doctors. Hong Kong: 2009

[12] Statistics and Workforce Planning Department. Hospital Authority Statistical Report (2011-2012) Hospital Authority, 2012:1-200.

Annex B

HEALTHCARE MANPOWER PLANNING AND PROJECTION (BASE YEAR 2017)

Projection Results and Observations of the Thirteen Professions Subject to Statutory Registration

Table of Contents

Foreword

In 2012, the Government set up a high-level steering committee (chaired by the then Secretary for Food and Health) to conduct the Strategic Review on Healthcare Manpower Planning and Professional Development. To assist the steering committee in making informed recommendations to the Government, we had commissioned Hong Kong University ("HKU") to conduct a comprehensive manpower projection for the 13 healthcare professions which were subject to statutory registration, including doctors, dentists and dental hygienists, nurses and midwives, Chinese medicine practitioners, pharmacists, occupational therapists, physiotherapists, medical laboratory technologists, optometrists, radiographers and chiropractors. The Report on the Strategic Review on Healthcare manpower Planning and Professional Development was then published in 2017.

Using the same projection model developed by HKU as in the previous exercise, the demand at the base year (i.e. 2017) is assumed to be at equilibrium, and takes into account known shortage in the public and subvented sectors for healthcare professionals as at end 2017. Future demand is derived with regard for demographic changes and other relevant factors including externalities and policy interventions through a sophisticated computer model, to which known and planned services and developments are incorporated. Future supply is derived from existing and planned local programmes as well as new registrants holding non-local qualifications. The demand projections so derived will then be compared with the estimated supply of healthcare professionals during the same period to see if any surplus or shortage of manpower exists.

The preliminary projection results for all the thirteen professions concerned are summarised in this report.

Background

Healthcare Workforce (as at end 2020)

1. Our health care system is supported by a team of dedicated healthcare professionals. As at end of 2020, there are over 112 000 healthcare professionals from the 13 professions which are subject to statutory registration.

Table 1 – The number of professionals from individual professions are as follows -

Doctors	15 298
Dentists	2 651
Dental Hygienists	497
Nurses	61 295
Midwives	4 561
Chinese Medicine Practitioners	10 422
Pharmacists	3 097
Occupational therapists	2 571
Physiotherapists	3 685
Medical Laboratory Technologists	3 983
Optometrists	2 266
Radiographers	2 554
Chiropractors	282

2. The majority of doctors, nurses, midwives, occupational therapists, physiotherapists, medical laboratory technologists and radiographers work in the public sector. Healthcare professionals more commonly engaged in the private sector include dentists, dental hygienists, Chinese Medicine practitioners, pharmacists, optometrists and chiropractors.

Increasing training places of the healthcare professions

3. In light of the ageing population and the general shortage of healthcare manpower in the past years, and at the same time, the provision of healthcare services has been expanding. Against this backdrop, the Government has already increased University Grants Committee (UGC)-funded places for doctors, nurses, pharmacists, and allied health professionals further since the 2009/10 triennium, with details as follows -

Table 2 – Number of UGC-training places for various professions

	2005/06 to 08/09	**2009/10 to 11/12**	**2012/13 to 15/16**	**2016/17 to18/19**	**2019/20 to 21/22**
Doctors	250	320	420	470	530
Dentists	53	53	53	73	80
Registered nurses	518-550	590	630	630	690
Occupational therapists	40	46	90	100	100
Physio-therapists	60	70	110	130	150
Medical laboratory technologists	35	32	44	54	54
Optometrists	35	35	35	40	45
Radiographers	35	48	98	110	110

4. As it takes time to train healthcare professionals and there is also limitation to the UGC-funded tertiary institutions to increase their training capacities in the short-to-medium term because of infrastructure constraints, the existing manpower gaps in various healthcare professions cannot be addressed simply through increasing publicly-funded training places.

Training period of healthcare professionals

Table 3 – Training period of different professions

Profession	Years of study (Year of internship required)
Doctors	6(1)
Dentists	6
Dental Hygienists	2
Registered Nurses (General)	5
Registered Nurses (Psychiatric)	2
Registered Chinese Medicine practitioners	6
Pharmacists	4(1)
Occupational therapists	4
Physiotherapists	4
Medical Laboratory Technologists	4
Optometrists	5
Radiographers	4

Self-financing sector

5. To meet the manpower shortage, the self-financing sector has taken on a bigger role over the years, for example, the launching of nursing degree programme offered by the Tung Wah College in 2012, and by the Caritas Institute of Higher Education in 2015, the launching of physiotherapist programme offered by Tung Wah College in 2018, and by the Open University of Hong Kong and Caritas Institute of Higher Education in 2020. We believe that providing a steady stream of locally trained graduates with a mix of UGC-funded and, where applicable, self-financing training places would be the most effective way of maintaining the supply for these professionals.

HKU's manpower projections

6. HKU has developed a generic manpower projection model that suits the local circumstances, and is adaptable to changing parameters to cater for differences in utilisation patterns among individual professions. The manpower projection model seeks to quantify the difference between the projected demand for and supply of healthcare professionals in terms of full time equivalents (FTEs).

HKU's Manpower Projection Model-

The projection of both demand and supply are represented diagrammatically as below -

Figure 1 – Demand Projection Model

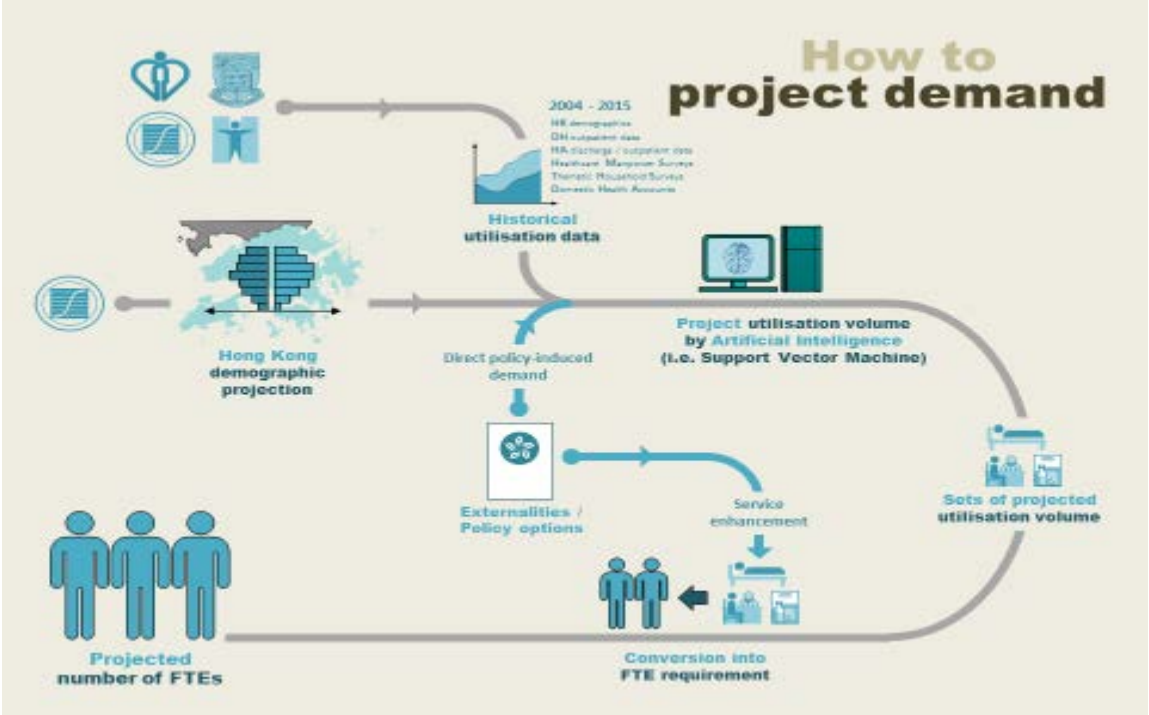


Figure 2 – Supply Projection Model

MANPOWER PROJECTION FOR EACH PROFESSION

Section 1 Doctors

1.1 The projections of manpower for doctors along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 3 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

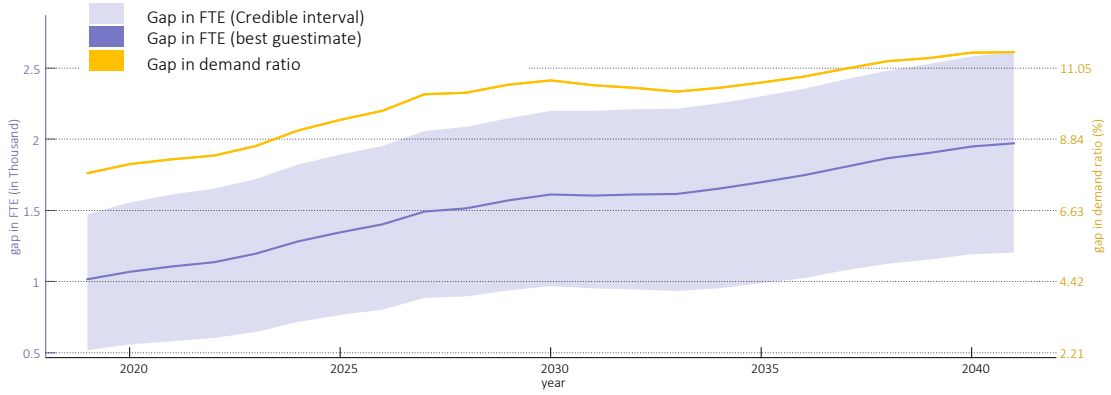


Table 4 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	560	764	967	991	1 192
(%)	(4.4)	(5.6)	(6.7)	(6.5)	(7.4)
Best guestimate	1 070	1 345	1 610	1 700	1 949
(%)	(8.1)	(9.4)	(10.7)	(10.6)	(11.5)
95th percentile	1 555	1 892	2 200	2 299	2 583
(%)	(11.3)	(12.8)	(14.0)	(13.8)	(14.7)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

Note:

Pre-existing manpower shortage in Hospital Authority and Department of Health, as well as Voluntary Health Insurance Scheme and new private hospitals development have been taken into account in this projection (Base year 2017).

1.2 Observations

As a result of prevalent demographic factors of population growth and ageing, coupled with growing burden of chronic diseases, manpower shortage of doctors persists and the gap further widens in the short- to medium-term comparing to the last projection.

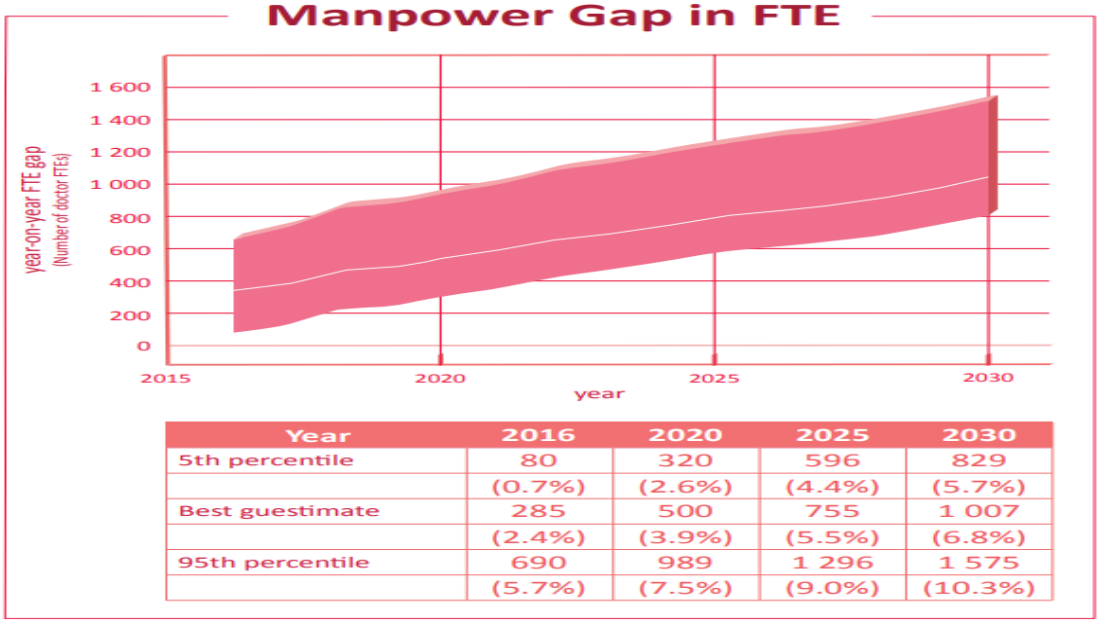
Even though there are already initiatives to increase the supply of both locally and non-locally trained doctors, the projection shows that the manpower shortage of doctors will not improve in short-to-medium term. We also note that shortfall in Hospital Authority from 2020 to 2040 are projected as in Table 5 -

Table 5 – Manpower shortfall of doctors in Hospital Authority from 2020 to 2040

Year	2020	2025	2030	2035	2040
FTE shortfall	660	730	800	880	960

No matter the overall situation in general, or the public sector (Hospital Authority) in particular, there is a significant shortfall of doctors.

Projection results of the last exercise are shown below for comparison:



Year	2016	2020	2025	2030
5th percentile	80	320	596	829
	(0.7%)	(2.6%)	(4.4%)	(5.7%)
Best guestimate	285	500	755	1 007
	(2.4%)	(3.9%)	(5.5%)	(6.8%)
95th percentile	690	989	1 296	1 575
	(5.7%)	(7.5%)	(9.0%)	(10.3%)

Section 2 Dentists

2.1 The projections of manpower for dentists along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 4 – Manpower Gap Projection in Full Time Equivalents from Year 2020 to 2041

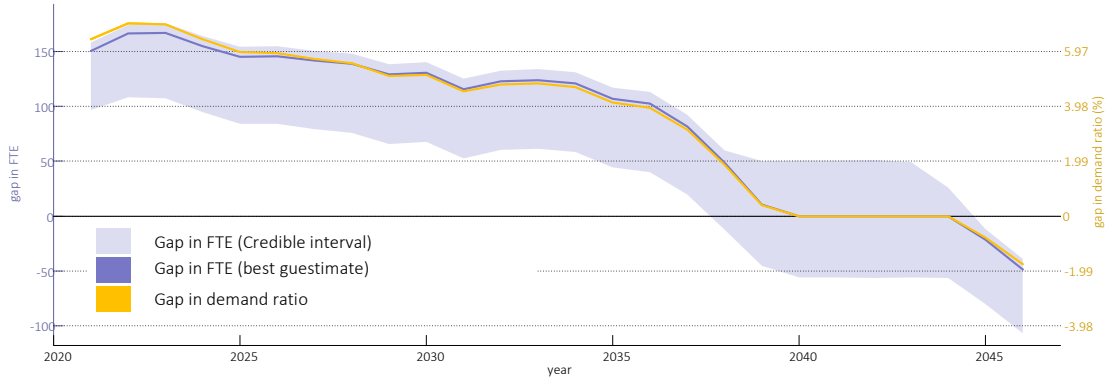


Table 6 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	**2020**	**2025**	**2030**	**2035**	**2040**
5th percentile	97	84	53	40	-56
(%)	(4.2)	(3.5)	(2.1)	(1.6)	(-2.1)
Best guestimate	150	146	115	102	0
(%)	(6.4)	(5.9)	(4.5)	(3.9)	(0)
95th percentile	158	155	125	113	51
(%)	(6.7)	(6.2)	(4.9)	(4.3)	(1.9)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

Note:

1. Quality improvement in Department of Health, Hospital Authority, and known and planned projects in public sector have been taken into account in this projection (Base year 2017).
2. The scenario of capacity for dental hygienists-substitutable basic dental service at private sector is also considered in this projection (Base year 2017)

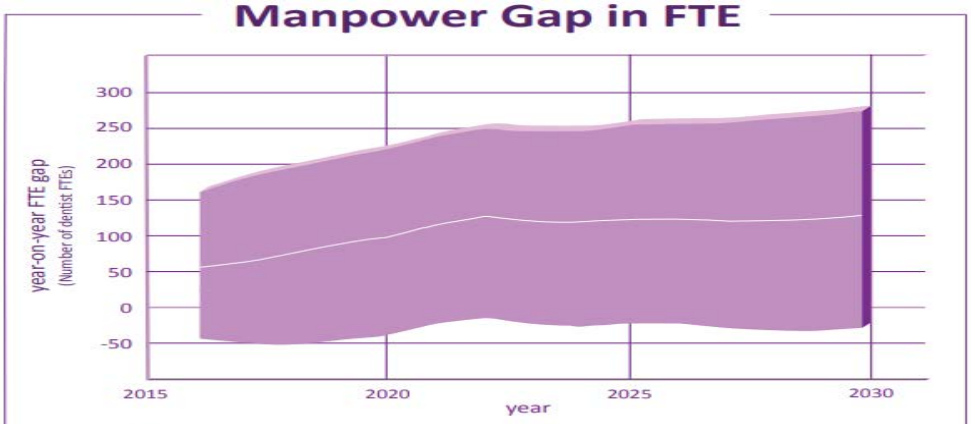
2.2 Observations

It is projected that a stable manpower shortage of dentists will be seen in the short- to-medium term, and the shortage will be less significant towards the end of the projection horizon. This is the result of the measures to increase supply of dentists that have been implemented since the last projection.

The inclusion of a new policy option of capacity for dental hygienist-substitutable basic dental service at private sector should be a better reflection of dentists demand. However, there is a caveat as the assumption is less than robust due to difficulty involved in the data of dental hygienists.

Meanwhile, the series of the newer initiatives to improve dental care in the community, namely Outreach Dental Care Programme for the Elderly, the Community Care Fund Elderly Dental Assistance Programme, and the Healthy Teeth Collaboration Programme for people with intellectual disabilities are already in place and included in this projection.

Projection results of the last exercise are shown below for comparison –



Year	2016	2020	2025	2030
5th percentile	-46	-42	-24	-31
	(-2.2%)	(-2.0%)	(-1.1%)	(-1.3%)
Best guestimate	53	96	121	127
	(2.5%)	(4.2%)	(5.1%)	(5.1%)
95th percentile	162	223	256	277
	(7.1%)	(9.2%)	(10.1%)	(10.5%)

Section 3 Dental Hygienists

3.1 The projections of manpower for dental hygienists along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 5 – Manpower Gap Projection in Full Time Equivalents from Year 2021 to 2041

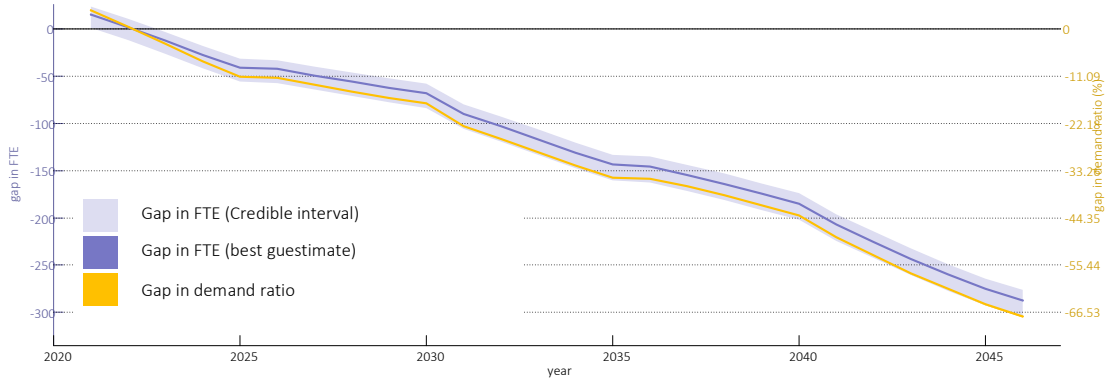


Table 7 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2021, 2025, 2030, 2035 and 2040

Year	**2021**	**2025**	**2030**	**2035**	**2040**
5th percentile	5	-52	-80	-156	-198
(%)	(1.5)	(-14.2)	(-20.4)	(-37.9)	(-46.7)
Best guestimate	15	-41	-68	-144	-185
(%)	(4.3)	(-11.2)	(-17.4)	(-34.9)	(-43.7)
95th percentile	24	-32	-58	-133	-174
(%)	(6.9)	(-8.6)	(-14.8)	(-32.3)	(-41.1)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

Note:

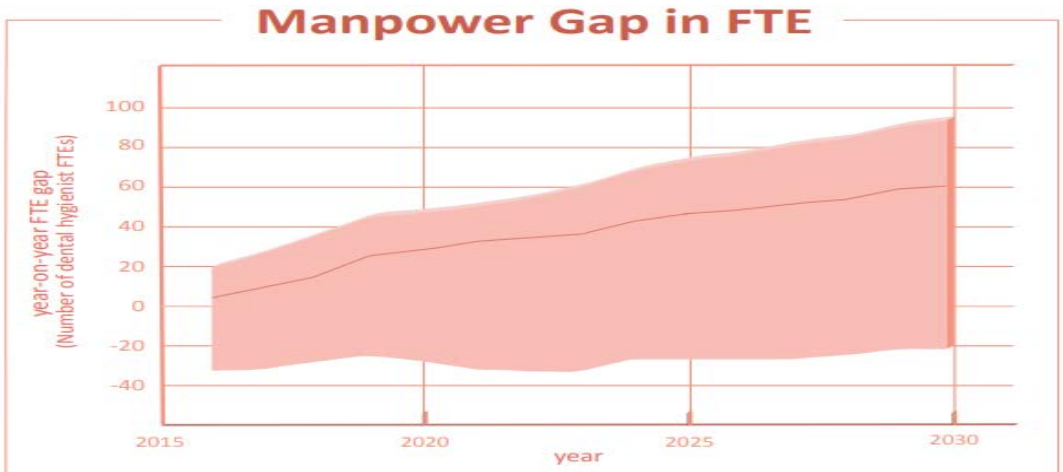
Retirement pattern with reference to Health Manpower Survey

3.2 Observations

An additional questionnaire survey for dental hygienists was conducted to obtain better estimates of hygienists who are active in the profession and the dental hygienist-specific utilisation data.

Meanwhile, discussions go on for a mechanism to update the registration status of dental hygienists, as they will stay on the list once enrolled, without the need for annual renewal.

Projection results of the last exercise are shown below for comparison:



Year	2016	2020	2025	2030
5th percentile	-31	-26	-25	-20
	(-11.2%)	(-7.9%)	(-6.5%)	(-4.6%)
Best guestimate	6	30	48	62
	(1.9%)	(7.8%)	(10.7%)	(12.2%)
95th percentile	22	49	75	95
	(6.7%)	(12.1%)	(15.7%)	(17.7%)

Section 4 Nurses

4.1 General Nurses

4.1.1 The projections of manpower for general nurses along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 6 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

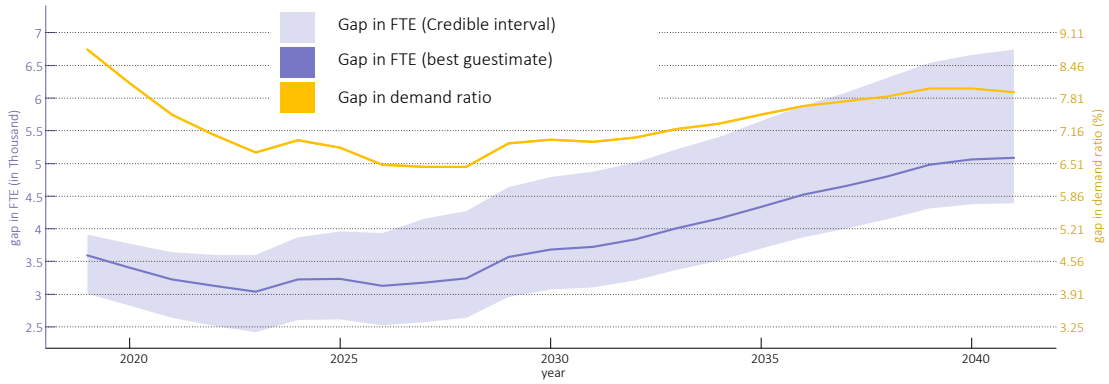


Table 8 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	**2020**	**2025**	**2030**	**2035**	**2040**
5th percentile	2 830	2 617	3 068	3 696	4 376
(%)	(6.8)	(5.6)	(5.9)	(6.4)	(7.0)
Best guestimate	3 405	3 235	3 679	4 337	5 060
(%)	(8.1)	(6.8)	(7.0)	(7.5)	(8.0)
95th percentile	3 776	3 959	4 793	5 651	6 663
(%)	(8.9)	(8.2)	(8.9)	(9.5)	(10.3)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

Note:

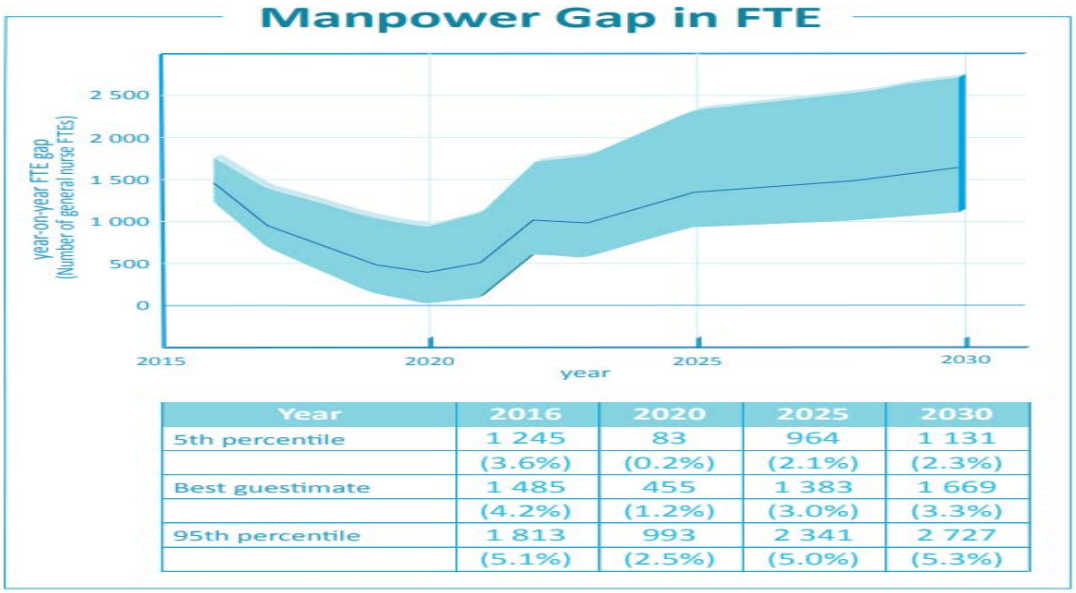
Pre-existing manpower shortage in Hospital Authority, Department of Health, new private hospitals development, known and planned social service projects in public and subvented sectors, Education Bureau, and growth of District Health Centres and Voluntary Health Insurance Scheme have been taken into account in this projection (Base year 2017).

4.1.2 Observations

The manpower gap is expected to further widen for general nurses in the short- to medium-term, reflecting the growing demands from both medical and welfare sectors, and from existing and newly planned services, despite the initiatives to increase the supply of general nurses that have been put in place over the past 10 years. The main bulk of the former comes from public hospitals, whereas the elderly and rehabilitation services demands, including those from new initiatives such as Elderly Service Programme Plan, are also steadily growing in the welfare sector.

Both University Grants Committee ("UGC") funded and self-financing places will be increased in the coming triennium, and the latter maintains a more flexible approach to increase training capacity of general nurses in response to the market demand timely.

Projection results of the last exercise are shown below for comparison:



Year	2016	2020	2025	2030
5th percentile	1 245	83	964	1 131
	(3.6%)	(0.2%)	(2.1%)	(2.3%)
Best guestimate	1 485	455	1 383	1 669
	(4.2%)	(1.2%)	(3.0%)	(3.3%)
95th percentile	1 813	993	2 341	2 727
	(5.1%)	(2.5%)	(5.0%)	(5.3%)

4.2 Psychiatric Nurses

4.2.1 The projections of manpower for psychiatric nurses along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 7 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

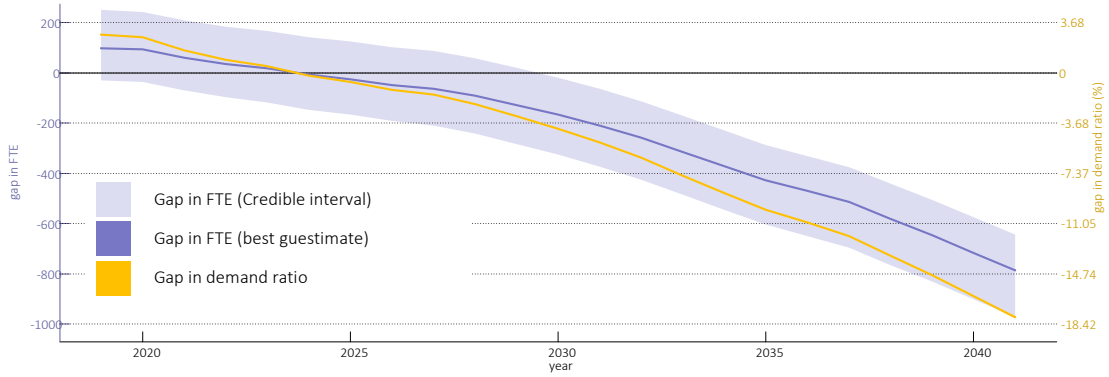


Table 9 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	-36	-167	-326	-605	-902
(%)	(-1.0)	(-4.5)	(-8.3)	(-14.9)	(-21.6)
Best guestimate	93	-26	-167	-427	-716
(%)	(2.6)	(-0.7)	(-4.1)	(-10.1)	(-16.4)
95th percentile	241	124	-20	-288	-575
(%)	(6.5)	(3.1)	(-0.5)	(-6.6)	(-12.7)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

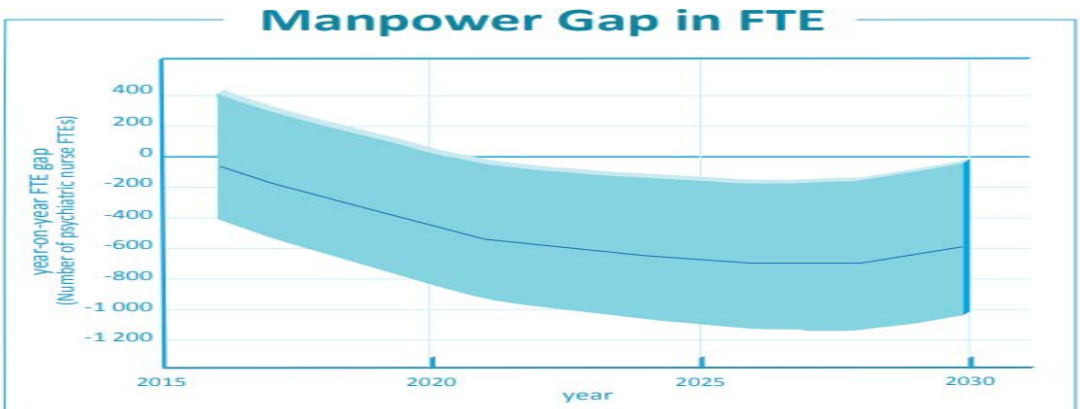
Note:

Growth of the Student Mental Health Support Scheme and welfare sector service have been taken into account in the present projection (Base year 2017).

4.2.2 Observations

The projected manpower gap of psychiatric nurses becomes narrowed in the medium-term comparing to the last projection, largely as a result of increasing demand for psychiatric nurses in both medical and welfare sectors.

Projection results of the last exercise are shown below for comparison:



Year	2016	2020	2025	2030
5th percentile	-441	-873	-1 131	-1 078
	(-16.1%)	(-30.1%)	(-35.9%)	(-31.6%)
Best guestimate	-94	-487	-708	-623
	(-3.0%)	(-14.8%)	(19.8%)	(-16.1%)
95th percentile	401	17	-174	-55
	(11.2%)	(0.4%)	(-4.2%)	(-1.2%)

Section 5 Midwives

5.1 The projections of manpower for midwives along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 8 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

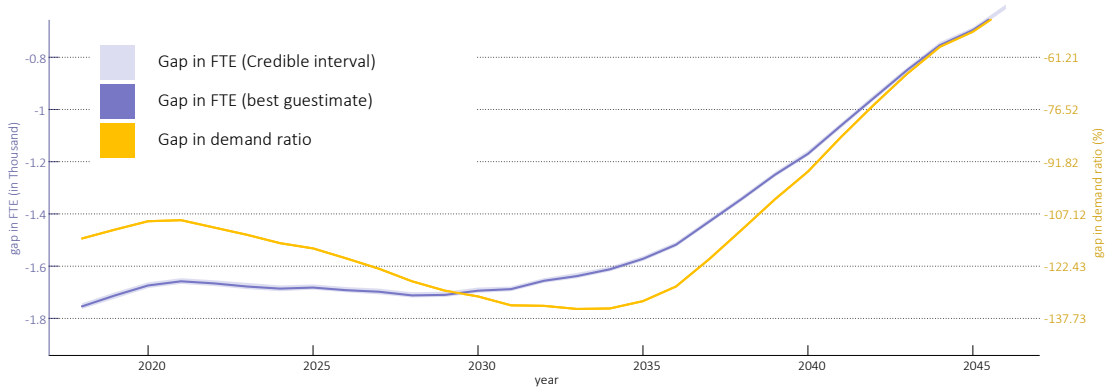


Table 10 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	-1 723	-1 696	-1 719	-1 620	-1 258
(%)	(-113.2)	(-117.1)	(-131.1)	(-136.4)	(-104.2)
Best guestimate	-1 755	-1 686	-1 710	-1 612	-1 250
(%)	(-111.8)	(-115.6)	(-129.6)	(-134.9)	(-102.9)
95th percentile	-1 742	-1 674	-1 699	-1 602	-1 240
(%)	(-110.0)	(-113.8)	(-127.7)	(-132.9)	(-101.2)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

5.2 Observations

Midwife demand is based on utilisation volume of pre-natal and live birth services, and is related to the number of newborns. Qualified midwives either practise solely in the midwifery profession, or as obstetric or general nurses. The former is defined as practice where eighty per cent or more of the working hours are in midwifery.

Health Manpower Survey reflects an increase in the number of midwives from 800 to 1 500 full-time equivalents from the year 2011 to 2014, mainly found in private institutions. However, the delivery figures are projected to be on a decreasing trend in Hong Kong. At this moment, the total number of registered midwives is around 4 511, which should be adequate for the years to come, given there are new entries each year from local 18-month post-registration diploma course, despite an anticipated retirement wave of midwives in the coming decade.

Section 6 Chinese Medicine Practitioners

6.1 The projections of manpower for Chinese Medicine Practitioners along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 9 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

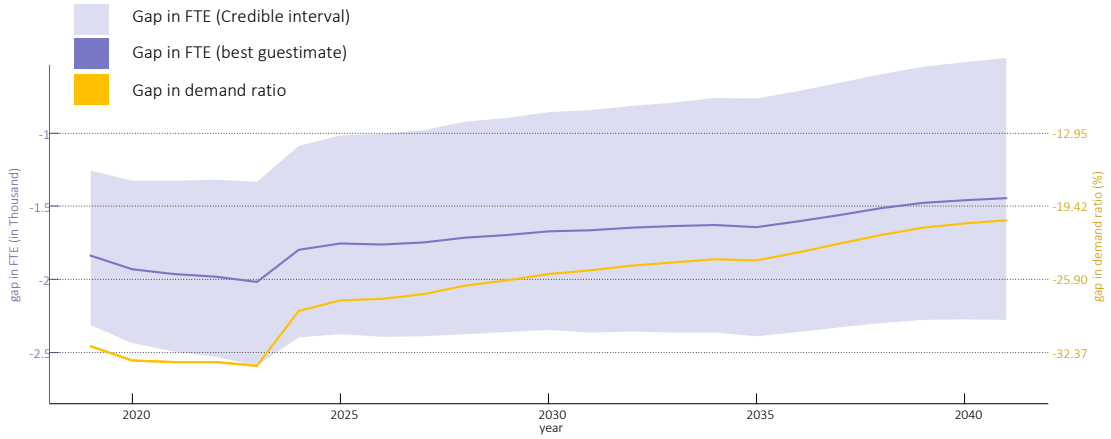


Table 11 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	-2 434	-2 375	-2 346	-2 389	-2 272
(%)	(-45.6)	(-41.4)	(-39.8)	(-39.4)	(-36.3)
Best guestimate	-1 931	-1 756	-1 671	-1 642	-1 458
(%)	(-33.1)	(-27.8)	(-25.4)	(-24.4)	(-21.0)
95th percentile	-1 325	-1 017	-857	-761	-515
(%)	(-20.5)	(-14.4)	(-11.5)	(-10.0)	(-6.5)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

Note:

1. Chinese Medicine Council of Hong Kong statistics: average no. of candidates passing licensing examination and getting registered is around 200 per year from 2012-2016, and increased to around 300 per year in 2018 and 2019.

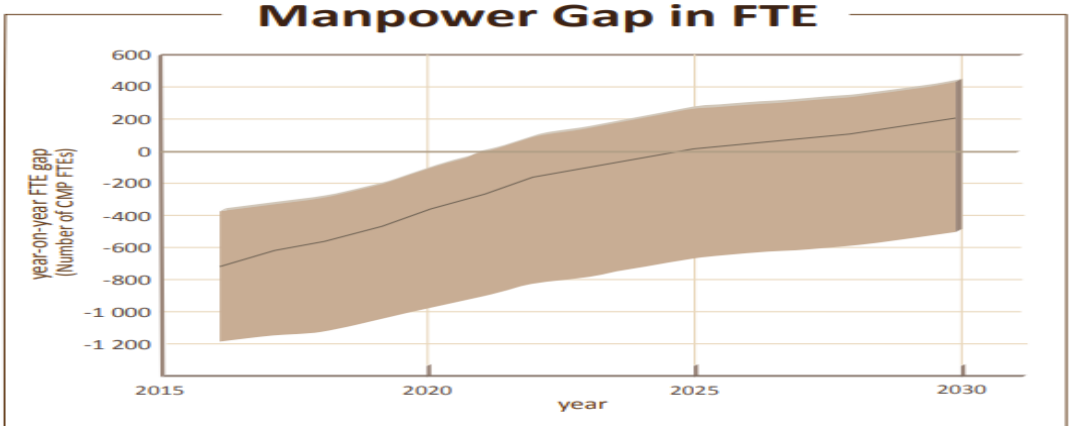
2. The number of students studying CM programmes in Mainland recognised by Chinese Medicine Council of Hong Kong has decreased from around 470 in 2013/14 to 260 in 2015/16, and to 245 in 2018/19.
3. Capacity in the private sector has been taken into account in this projection (Base year 2017).

6.2 Observations

Despite an increase demand of Chinese Medicine Practitioners in the public sector with the opening of Chinese Medicine Hospital in 2025, the demand in the private sector continue to remain stable. Taking into account the capacity in the private sector (specifically in the private outpatient setting), an adequate supply of Chinese Medicine Practitioners is projected in both short- to- medium term.

On the supply side, it is observed that there is a decreasing trend of studying Chinese Medicine in recognised schools in Mainland over the last five years, whereas the number of non-local registered Chinese Medicine Practitioners remains stable.

Projection results of the last exercise are shown below for comparison:



Year	2016	2020	2025	2030
5th percentile	-1 198	-984	-673	-505
	(-18.7%)	(-14.8%)	(-9.8%)	(-7.2%)
Best guestimate	-716	-354	25	222
	(-10.4%)	(-4.9%)	(0.3%)	(2.9%)
95th percentile	-359	-82	287	451
	(-4.9%)	(-1.1%)	(3.7%)	(5.7%)

Section 7 Pharmacists

7.1 The projections of manpower for pharmacists along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 10 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

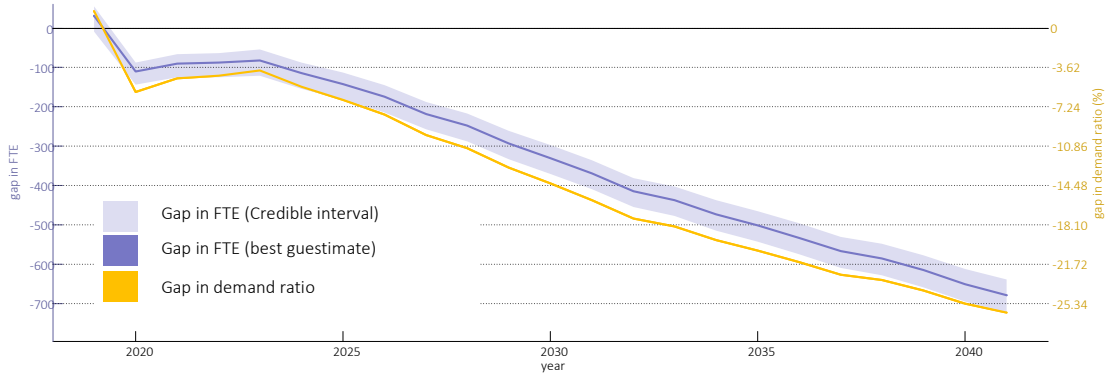


Table 12 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	-143	-182	-370	-543	-696
(%)	(-7.8)	(-8.6)	(-16.3)	(-22.5)	(-27.5)
Best guestimate	-110	-142	-330	-502	-652
(%)	(-5.9)	(-6.6)	(-14.3)	(-20.5)	(-25.3)
95th percentile	-87	-113	-298	-465	-613
(%)	(-4.6)	(-5.2)	(-12.7)	(-18.7)	(-23.5)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

Note:

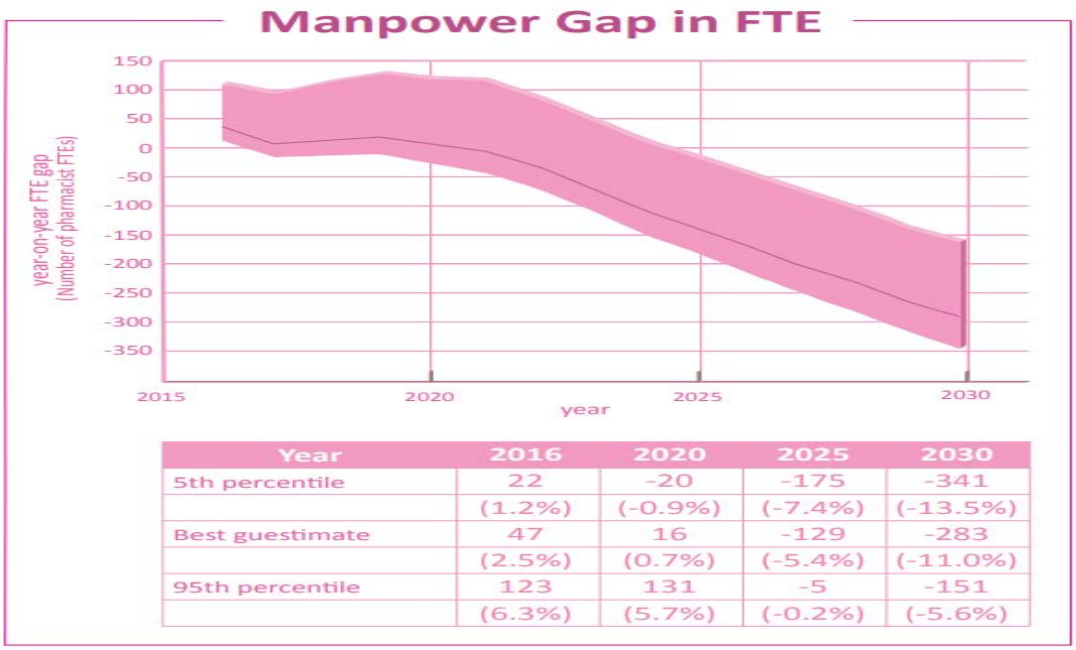
Retirement pattern with reference to Health Manpower Survey.

7.2 Observations

According to the projection results, the demand on public hospitals inpatient, specialty outpatient and general outpatient dispensing services are all growing along the projection horizon, especially those for inpatients. An adequate supply of pharmacists however, are projected in both short-to- medium term from year 2020 onwards.

This is in commensurate with the decrease in demand of community pharmacists due to economic downturn and a reduced demand from tourists, whereas the supply for local graduates remain steady.

Projection results of the last exercise are shown below for comparison:



Year	2016	2020	2025	2030
5th percentile	22	-20	-175	-341
	(1.2%)	(-0.9%)	(-7.4%)	(-13.5%)
Best guestimate	47	16	-129	-283
	(2.5%)	(0.7%)	(-5.4%)	(-11.0%)
95th percentile	123	131	-5	-151
	(6.3%)	(5.7%)	(-0.2%)	(-5.6%)

Section 8 Occupational Therapists

8.1 The projections of manpower for occupational therapists along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 11 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

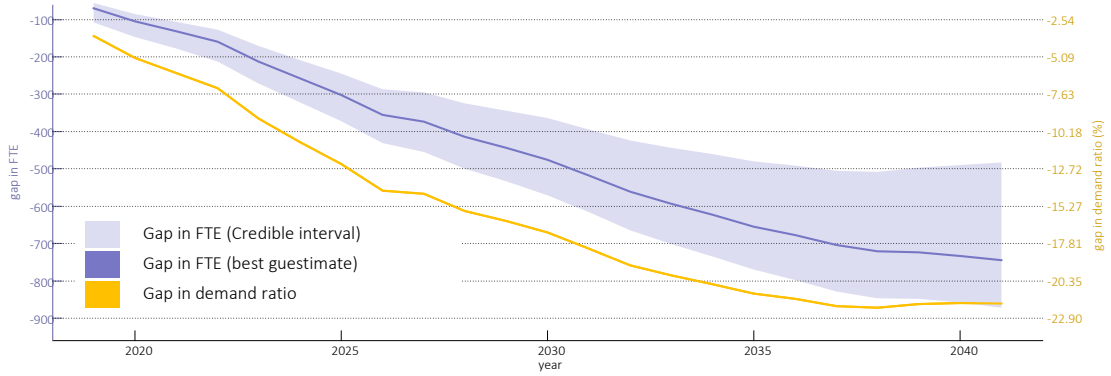


Table 13 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	-6.7	-176	-349	-516	-576
(%)	(-0.34)	(-7.2)	(-12.4)	(-16.5)	(-16.7)
Best guestimate	-6.6	-172	-336	-489	-536
(%)	(-0.33)	(-7.0)	(-11.8)	(-15.5)	(-15.3)
95th percentile	-6.5	-167	-324	-470	-515
(%)	(-0.33)	(-6.8)	(-11.4)	(-14.8)	(-14.6)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

Note:

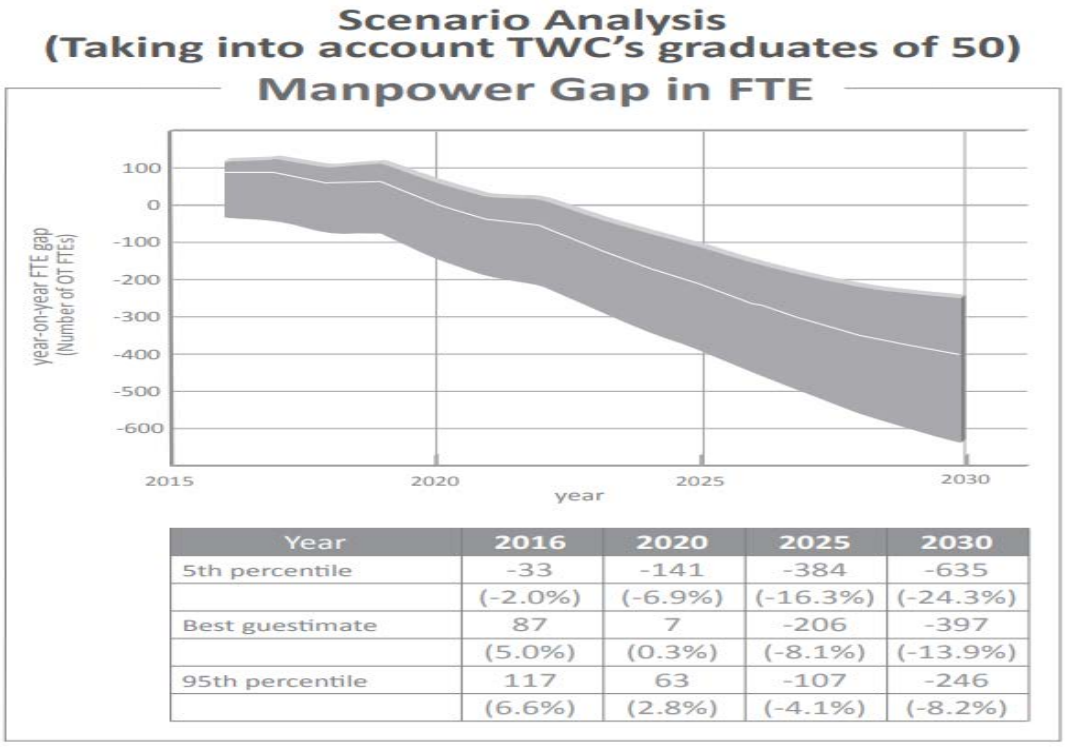
1. Quality improvement in Hospital Authority, known and planned projects in public and subvented sectors, and District Health Centres requirements have been taken into account in this projection (Base year 2017).
2. An over-estimation of demand is noted in the last projection due to an erroneous staffing ratio figure for infirmary unit attached to care and attention homes.

8.2 Observations

Despite demand for occupational therapists is rising in both medical and welfare sectors, however, given the increasing supply from Tung Wah College (from 2017), an equilibrium of occupational therapist manpower in the short-term with an adequate supply in the medium-term is found in the present projection.

The Master in Occupational Therapy programme graduates (started 2012) remains a significant source of manpower as reported by stakeholders from non-governmental organisations.

Projection results of the last exercise are shown below for comparison:



Year	2016	2020	2025	2030
5th percentile	-33	-141	-384	-635
	(-2.0%)	(-6.9%)	(-16.3%)	(-24.3%)
Best guestimate	87	7	-206	-397
	(5.0%)	(0.3%)	(-8.1%)	(-13.9%)
95th percentile	117	63	-107	-246
	(6.6%)	(2.8%)	(-4.1%)	(-8.2%)

Section 9 Physiotherapists

9.1 The projections of manpower for physiotherapists along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 12 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

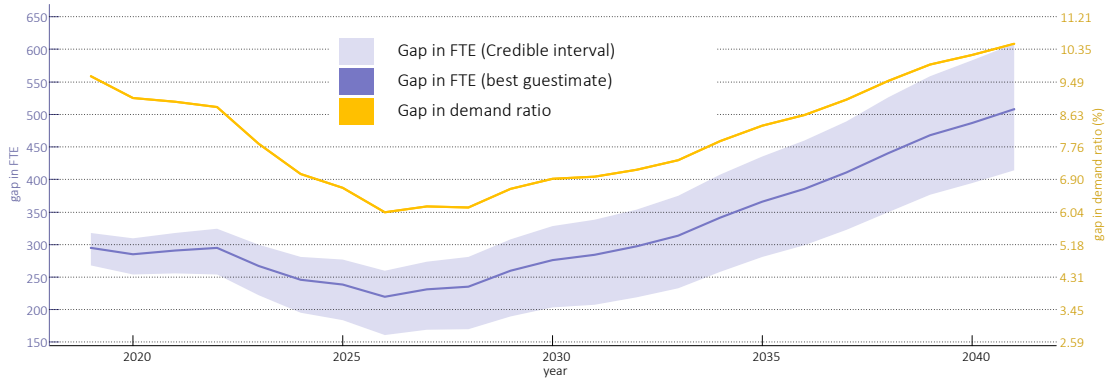


Table 14 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	254	184	204	281	395
(%)	(8.1)	(5.2)	(5.2)	(6.5)	(8.4)
Best guestimate	285	239	276	366	487
(%)	(9.1)	(6.7)	(6.9)	(8.3)	(10.2)
95th percentile	310	277	328	436	583
(%)	(9.8)	(7.7)	(8.1)	(9.8)	(12.0)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

Note:

Quality improvement in Hospital Authority, known and planned projects in the public and welfare sectors, and District Health Centres requirements have been taken into account in this projection (Base year 2017).

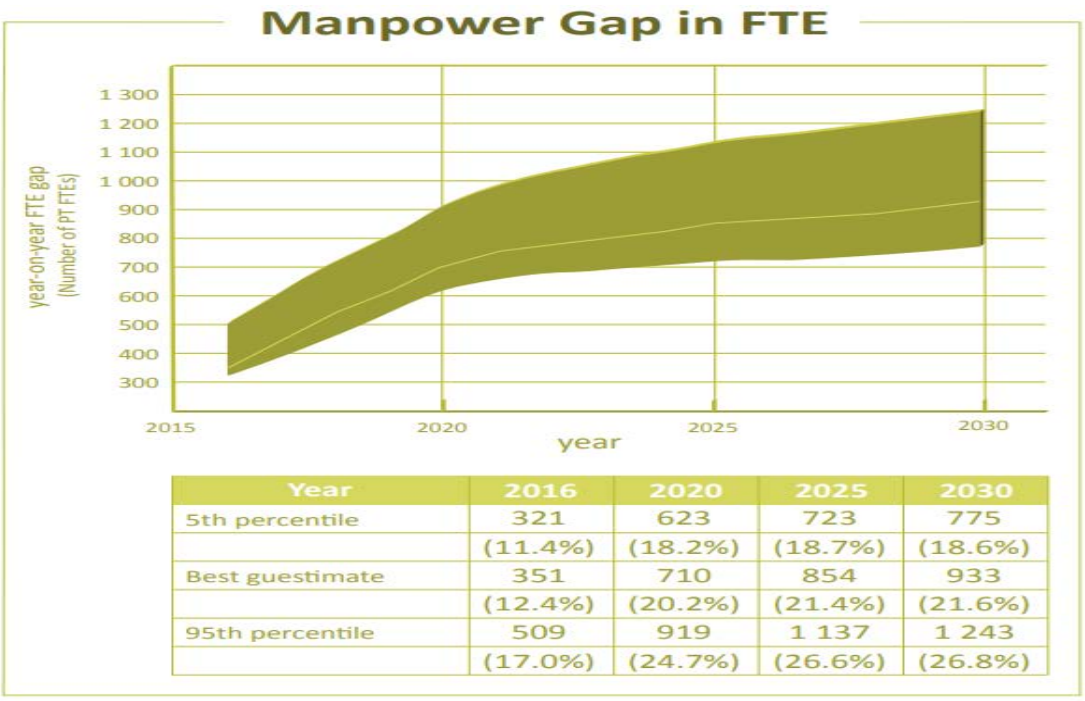
9.2 Observations

A shortfall of physiotherapists is noted in both short- to medium-term, as a result of increasing demand in both medical and welfare sectors, though the gap narrows in both short- and medium-term compared with the last projection.

The Master in Physiotherapy programme graduates (started 2012) remains a significant source of manpower as reported by stakeholders from non-governmental organisations.

There will be an adequate manpower expected due to additional supply from Open University and Caritas Institute of Higher Education with a total of 90 graduates per year from year 2024 onwards.

Projection results of the last exercise are shown below for comparison:



Year	2016	2020	2025	2030
5th percentile	321	623	723	775
	(11.4%)	(18.2%)	(18.7%)	(18.6%)
Best guestimate	351	710	854	933
	(12.4%)	(20.2%)	(21.4%)	(21.6%)
95th percentile	509	919	1 137	1 243
	(17.0%)	(24.7%)	(26.6%)	(26.8%)

Section 10 Medical Laboratory Technologists

10.1 The projections of manpower for medical laboratory technologists along the projection horizon are shown in the following Figure and Table.

Base case and Policy options

Figure 13 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

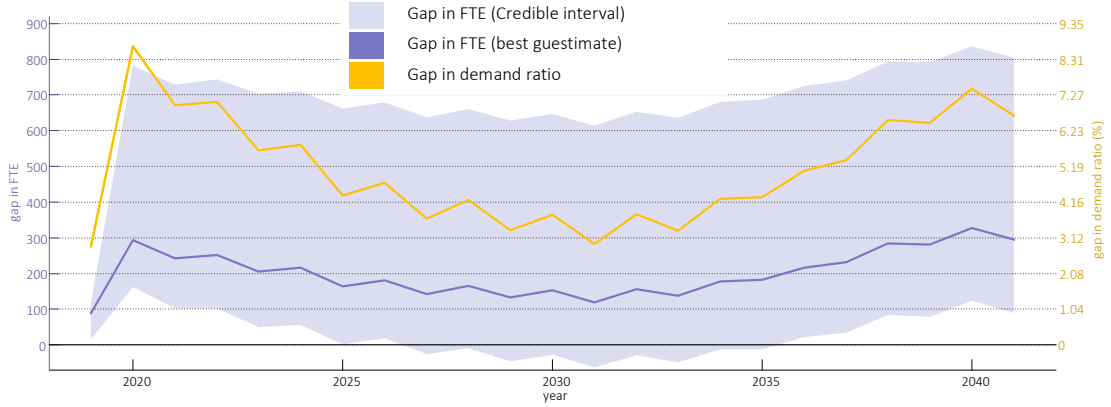


Table 15 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	162	2	-28	-11	124
(%)	(5.0)	(0.1)	(-0.7)	(-0.3)	(3.0)
Best guestimate	294	164	153	182	328
(%)	(8.7)	(4.3)	(3.8)	(4.3)	(7.5)
95th percentile	783	662	647	688	837
(%)	(20.2)	(15.5)	(14.3)	(14.5)	(17.1)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

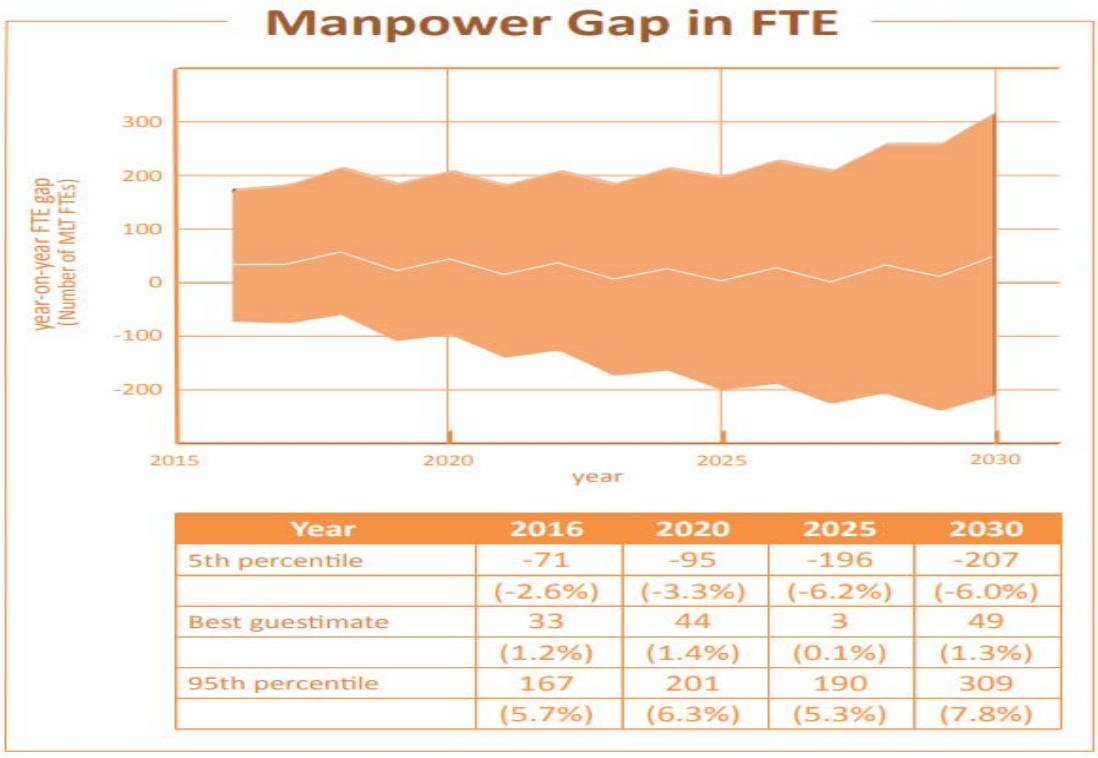
Note:

1. Pre-existing manpower shortage in Department of Health has been taken into account in this projection (Base year 2017).
2. The impact of COVID-19 as policy option has been included.

10.2 Observations

Taking into account the extra surge in demand for healthcare services in both public and private sectors as a result of COVID-19, a significant increase in medical laboratory technologist manpower shortage is anticipated in both short- and medium-term, provided that the prevailing outbreak is present.

Projection results of the last exercise are shown below for comparison:



Year	2016	2020	2025	2030
5th percentile	-71	-95	-196	-207
	(-2.6%)	(-3.3%)	(-6.2%)	(-6.0%)
Best guestimate	33	44	3	49
	(1.2%)	(1.4%)	(0.1%)	(1.3%)
95th percentile	167	201	190	309
	(5.7%)	(6.3%)	(5.3%)	(7.8%)

Section 11 Optometrists

11.1 The projections of manpower for optometrists along the projection horizon are shown in the following Figure and Table.

Base case

Figure 14 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

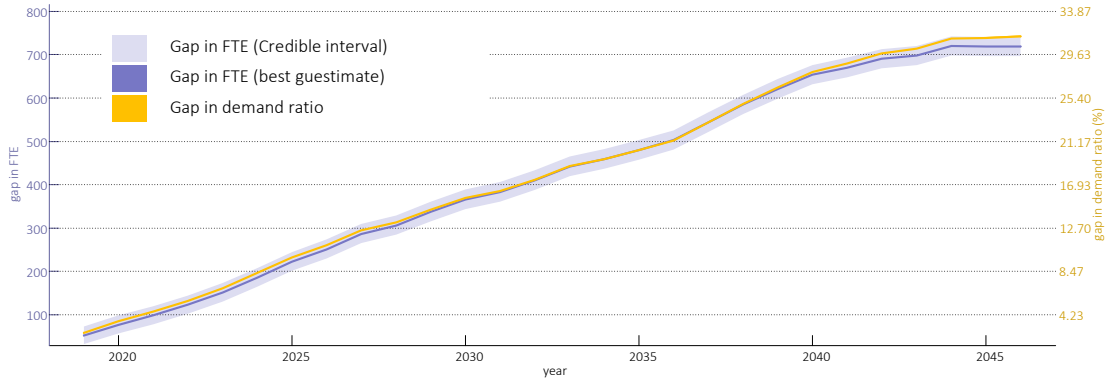


Table 16 – Summary of Manpower Gap in Full Time Equivalents numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	57	202	344	458	632
(%)	(2.7)	(9.0)	(14.8)	(19.6)	(27.2)
Best guestimate	77	223	366	480	654
(%)	(3.6)	(9.8)	(15.6)	(20.3)	(27.9)
95th percentile	98	245	389	504	676
(%)	(4.5)	(10.7)	(16.4)	(21.1)	(28.6)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

Note:

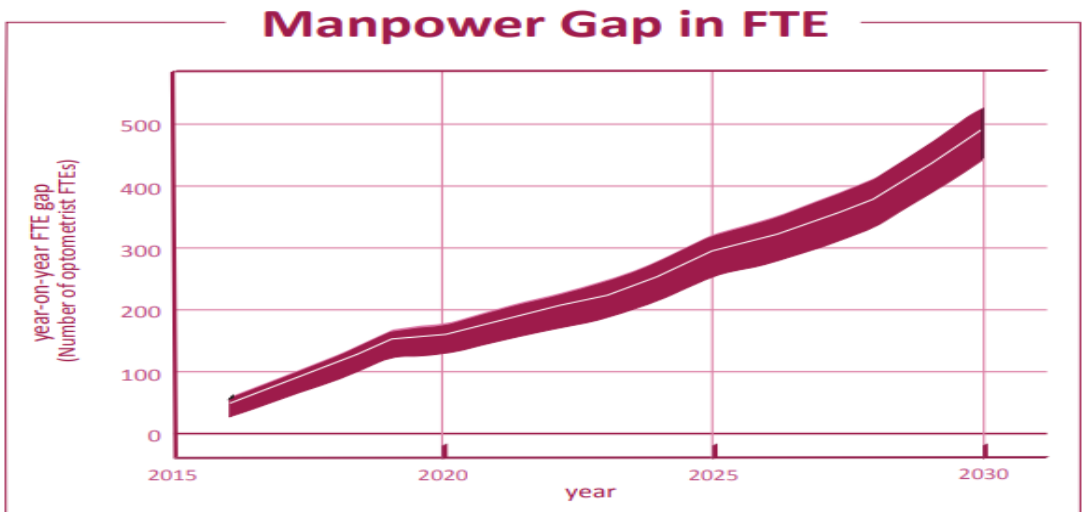
Retirement pattern with reference to Health Manpower Survey.

11.2 Observations

Optometrist supply drops substantially from 2017 onwards as a result of cohort retirement, increasing the manpower gap along the projection horizon. On the other hand, optometrist demand is projected to peak at year 2035 and decline thereafter.

As the majority of optometrists are in private practice, some degree of supply flexibility exists due to variable retirement age and changing work patterns.

Projection results of the last exercise are shown below for comparison -



Year	2016	2020	2025	2030
5th percentile	31	134	259	446
	(1.7%)	(7.0%)	(13.2%)	(22.2%)
Best guestimate	56	167	302	497
	(3.0%)	(8.6%)	(15.0%)	(24.1%)
95th percentile	63	181	326	533
	(3.3%)	(9.2%)	(16.0%)	(25.4%)

Section 12 Radiographers

12.1 The projections of manpower for radiographers along the projection horizon are shown in the following Figure and Table.

Base case

Figure 15 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

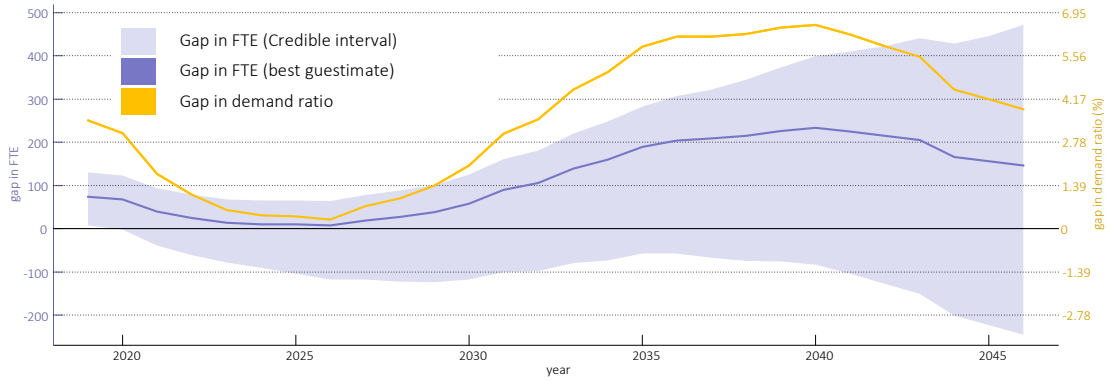


Table 17 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	-3	-103	-118	-58	-83
(%)	(-0.1)	(-4.3)	(-4.4)	(-1.9)	(-2.6)
Best guestimate	68	10	59	190	233
(%)	(3.1)	(0.4)	(2.0)	(5.9)	(6.6)
95th percentile	123	66	125	282	399
(%)	(5.5)	(2.5)	(4.3)	(8.4)	(10.7)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

Note:

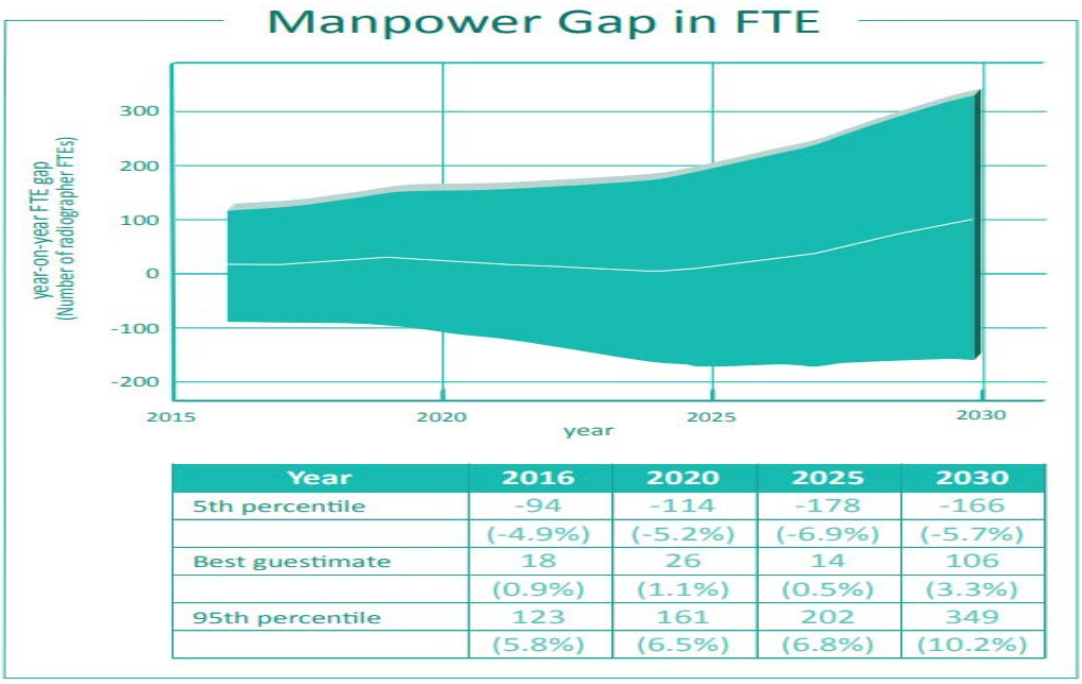
Retirement pattern with reference to Health Manpower Survey.

12.2 Observations

An equilibrium or slight narrowing in manpower gap for radiographers is projected, partly due to the increased supply since 2016 from Tung Wah College, which now have 25 graduates per year.

However, shortage for radiographers in the diagnostic stream remains significant from year 2028 onwards, despite a short-term slight surplus, and more evident than those in the therapeutic stream, due to increasing demand from both public and private sectors.

Projection results of the last exercise are shown below for comparison -



Year	2016	2020	2025	2030
5th percentile	-94	-114	-178	-166
	(-4.9%)	(-5.2%)	(-6.9%)	(-5.7%)
Best guestimate	18	26	14	106
	(0.9%)	(1.1%)	(0.5%)	(3.3%)
95th percentile	123	161	202	349
	(5.8%)	(6.5%)	(6.8%)	(10.2%)

Section 13 Chiropractors

13.1 The projections of manpower for chiropractors along the projection horizon are shown in the following Figure and Table.

Base case

Figure 16 – Manpower Gap Projection in Full Time Equivalents from Year 2019 to 2041

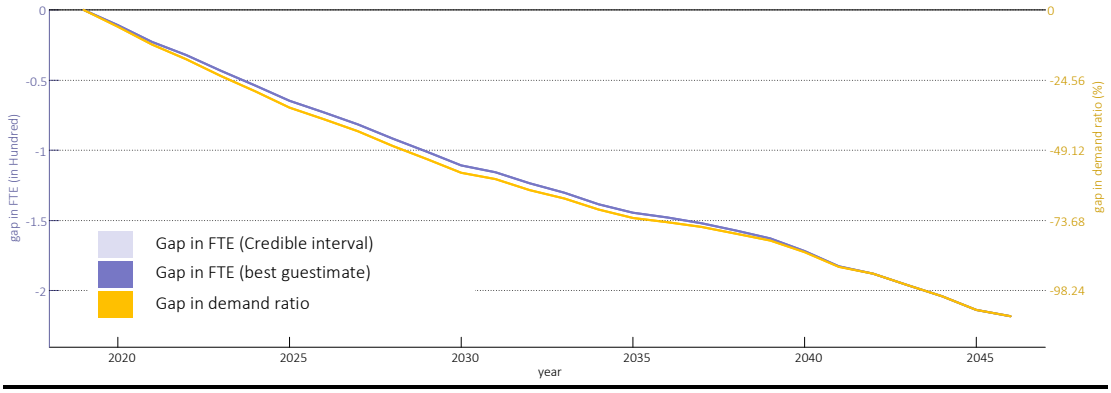


Table 18 – Summary of Manpower Gap in Full Time Equivalents Numbers in Year 2020, 2025, 2030, 2035 and 2040

Year	2020	2025	2030	2035	2040
5th percentile	-10	-62	-105	-137	-163
(%)	(-5.5)	(-32.5)	(-54.1)	(-69.2)	(-80.6)
Best guestimate	-11	-65	-111	-145	-172
(%)	(-5.8)	(-34.2)	(-57.0)	(-72.8)	(-84.8)
95th percentile	-11	-68	-116	-152	-180
(%)	(-6.1)	(-35.9)	(-59.9)	(-76.4)	(-89.0)

-positive number indicates shortfall, negative number indicates surplus;

-(%): the shortfall or surplus expressed as percentage of demand in the omnibus scenario.

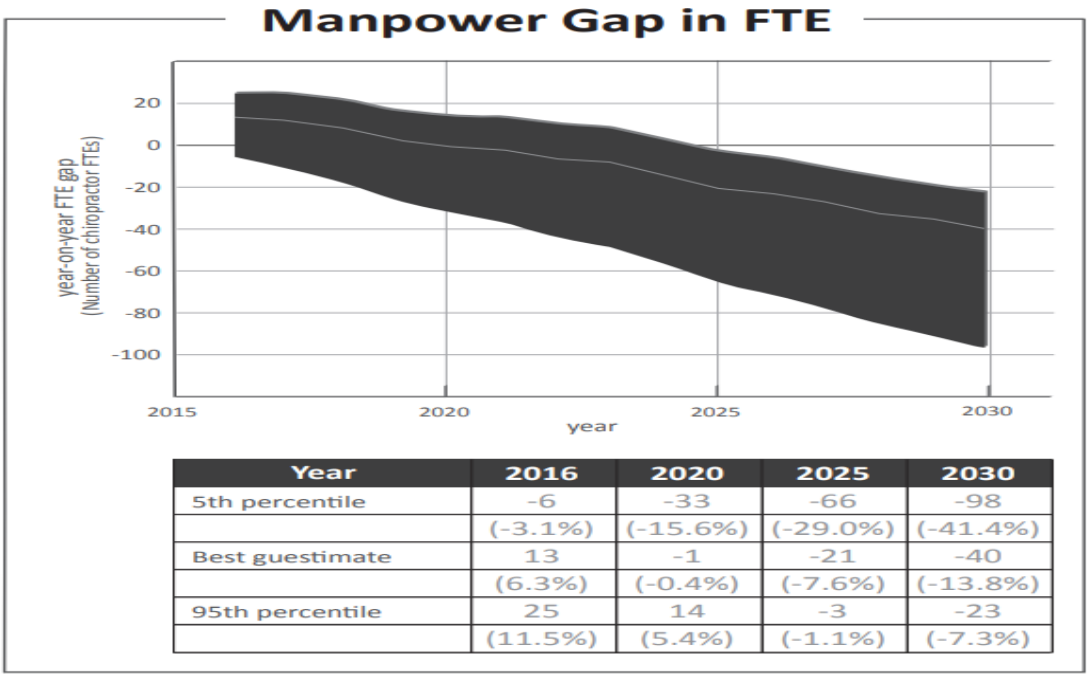
Note:

Results of the survey on chiropractors in 2020 have been accounted for in the present projection

13.2 Observations

An adequate supply of chiropractors is evident in both short- to-medium term from year 2020 onwards due to increasing supply of new registrants graduated from overseas. The growth on demand remains slow on the other hand.

Projection results of the last exercise are shown below for comparison -



Year	2016	2020	2025	2030
5th percentile	-6	-33	-66	-98
	(-3.1%)	(-15.6%)	(-29.0%)	(-41.4%)
Best guestimate	13	-1	-21	-40
	(6.3%)	(-0.4%)	(-7.6%)	(-13.8%)
95th percentile	25	14	-3	-23
	(11.5%)	(5.4%)	(-1.1%)	(-7.3%)

Food and Health Bureau
March 2021

Annex C

HEALTHCARE MANPOWER PLANNING AND PROJECTION

BASE YEAR 2017

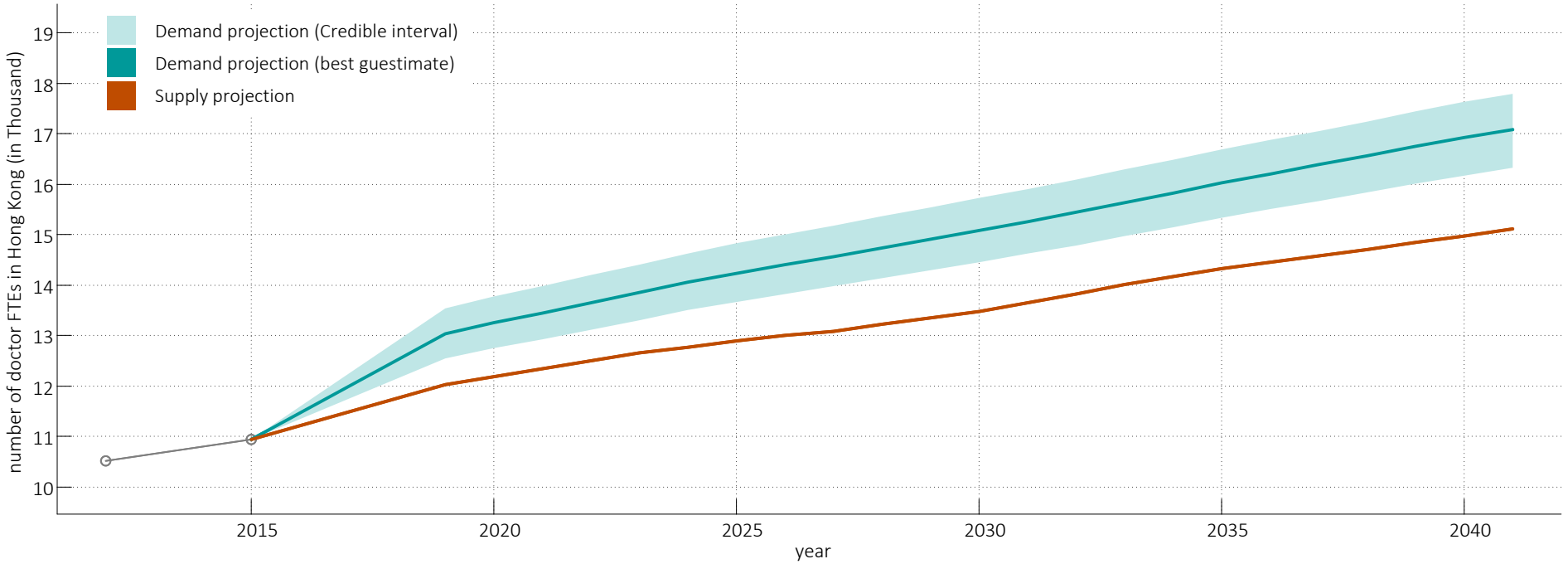
March 12, 2021

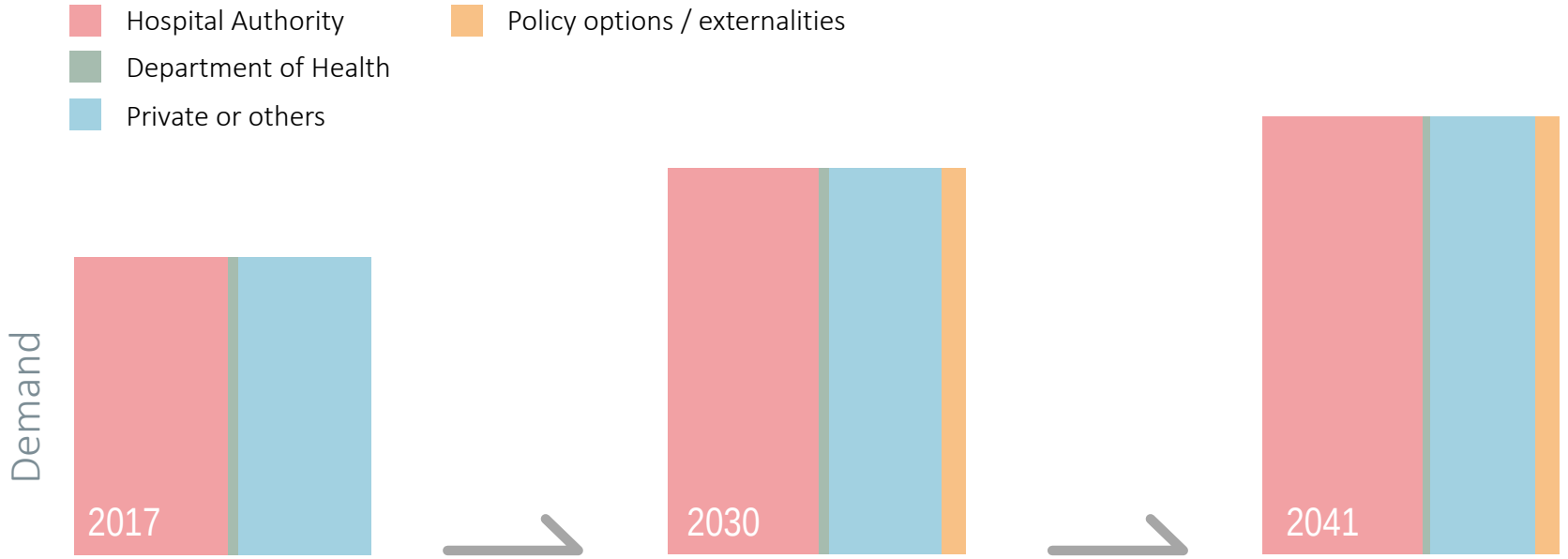
HKU Med
LKS Faculty of Medicine
School of Public Health
香港大學公共衞生學院

What's new?

- Acquired utilisation pattern of **Physiotherapist / Occupational therapist / Optometrist / Chiropractor** through survey-based approach
- Acquired work pattern of dental hygienist through survey-based approach to which the supply projection model is consistent with other professions
- Applied utilisation-based approach to project dental hygienist demand

Doctor



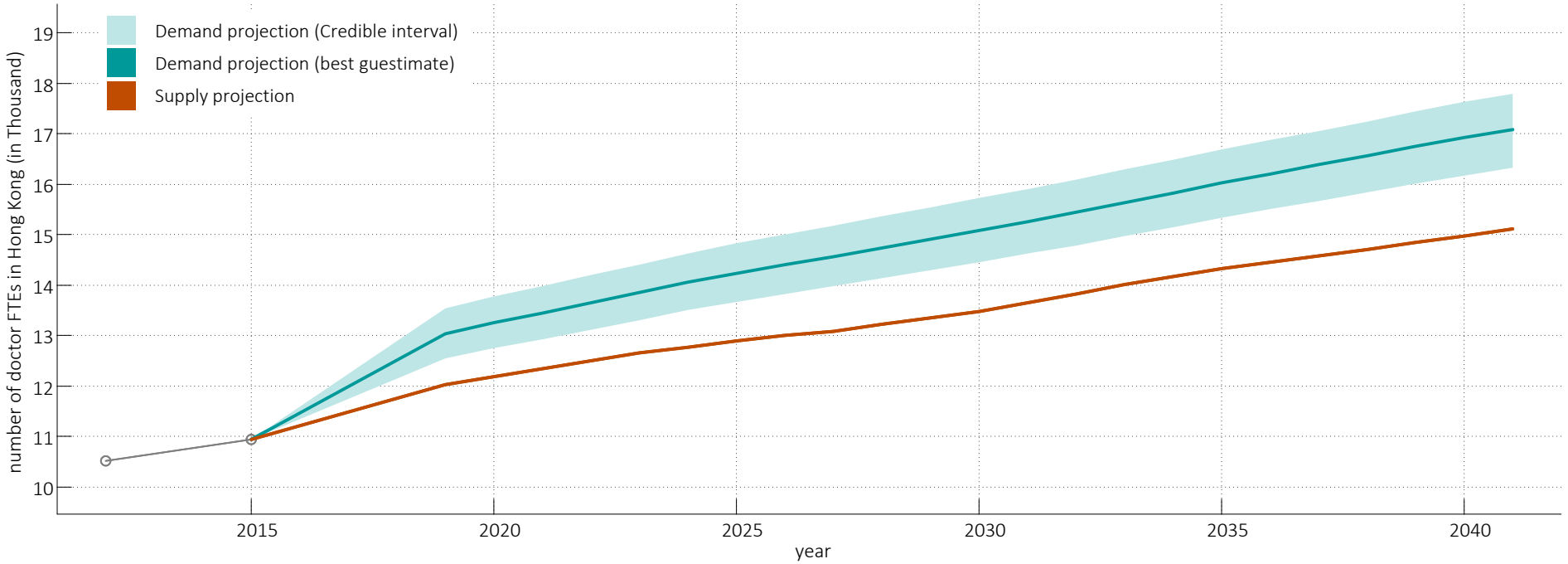


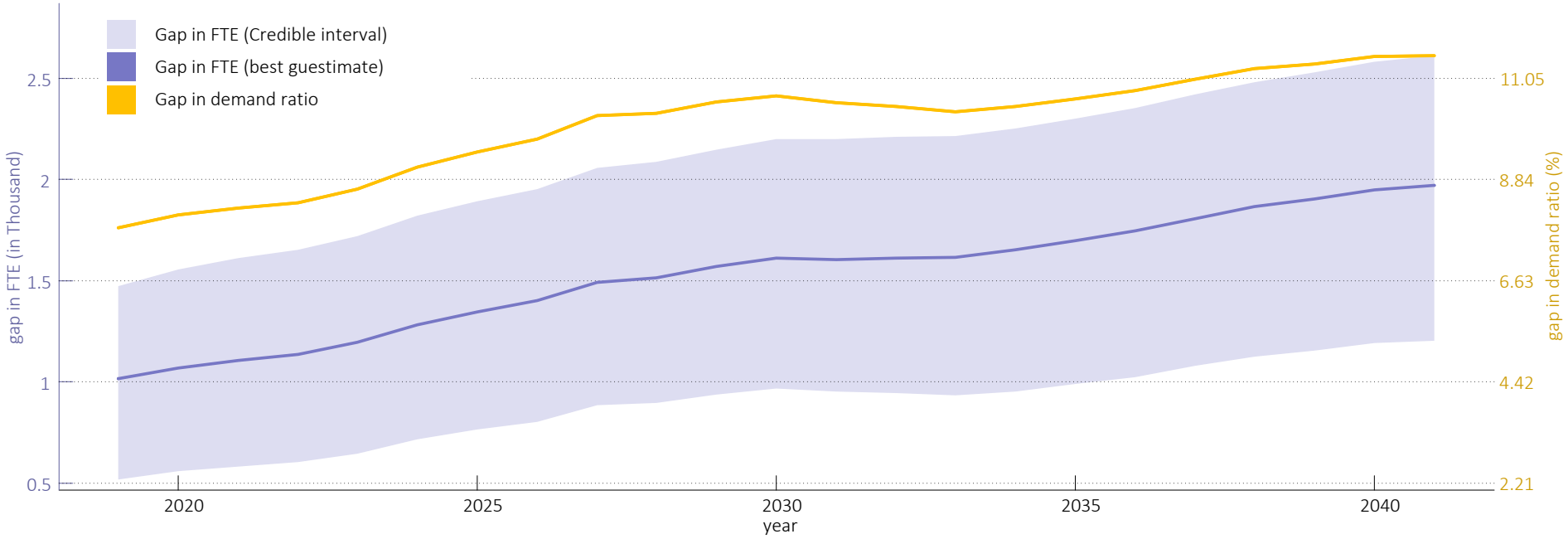
Policy options | Externalities

- Historical Manpower Shortage (Hospital Authority)
- Historical Manpower Shortage (Department of Health)
- New Private Hospitals
- Voluntary Health Insurance Scheme

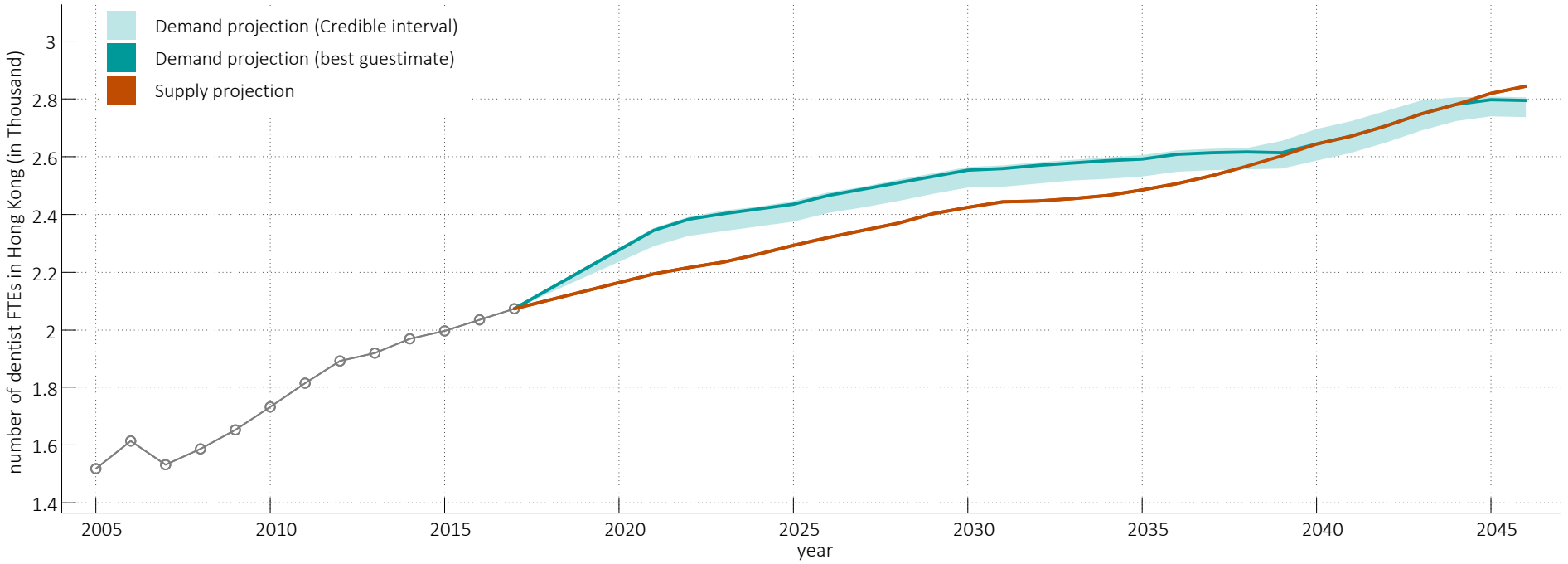
Doctor

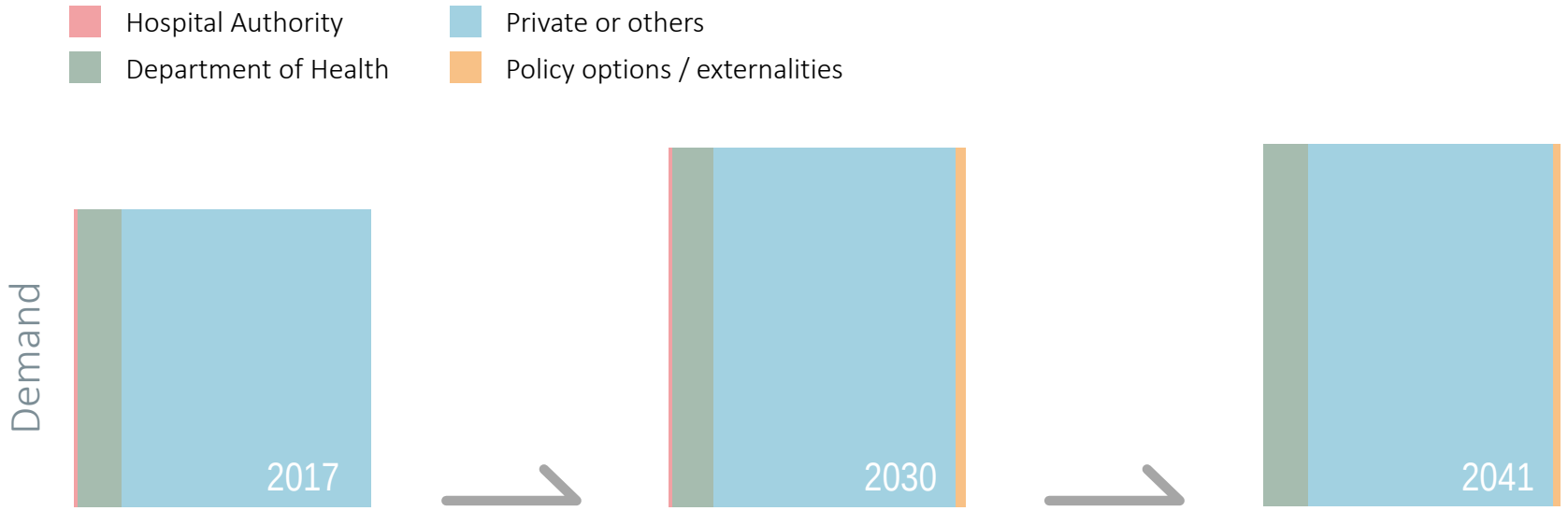
GAP ANALYSIS





Dentist



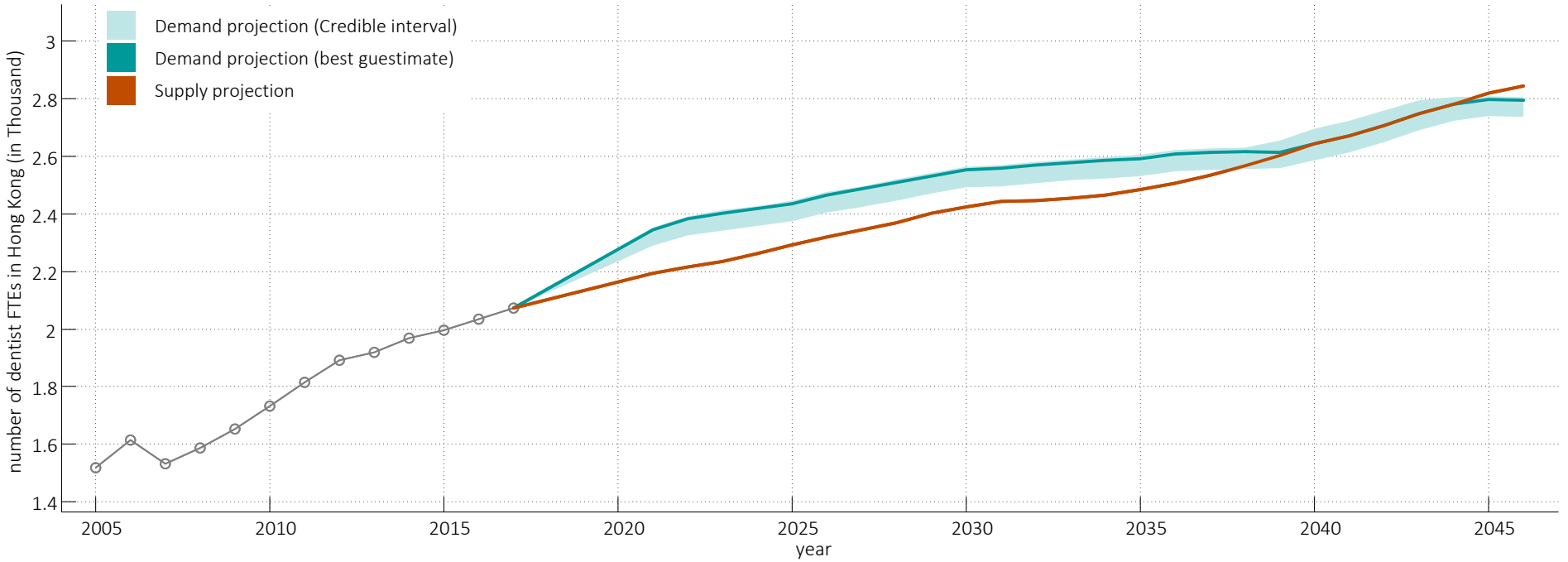


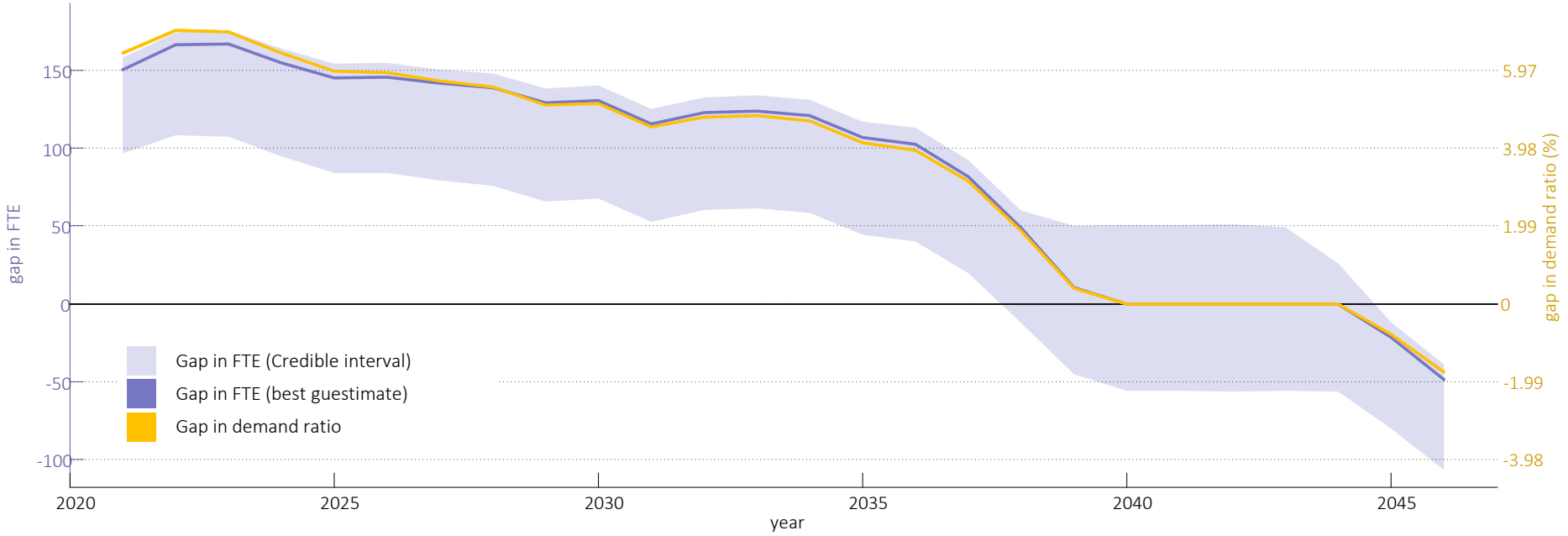
Policy options | Externalities

- Service enhancement (Hospital Authority)
- Service enhancement (Department of Health)
- Healthy Teeth Programme
- Elderly Dental Assistance Programme
- Outreach Dental Service for the Elderly
- Service substitution by dental hygienist

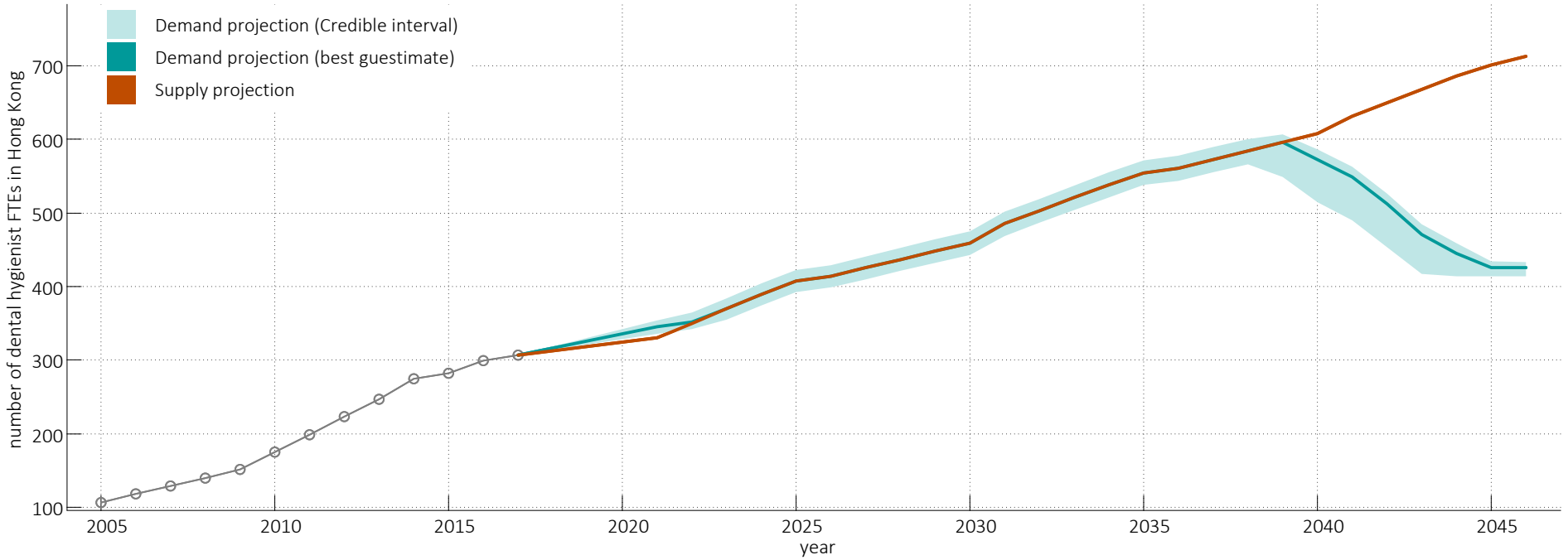
Dentist

GAP ANALYSIS



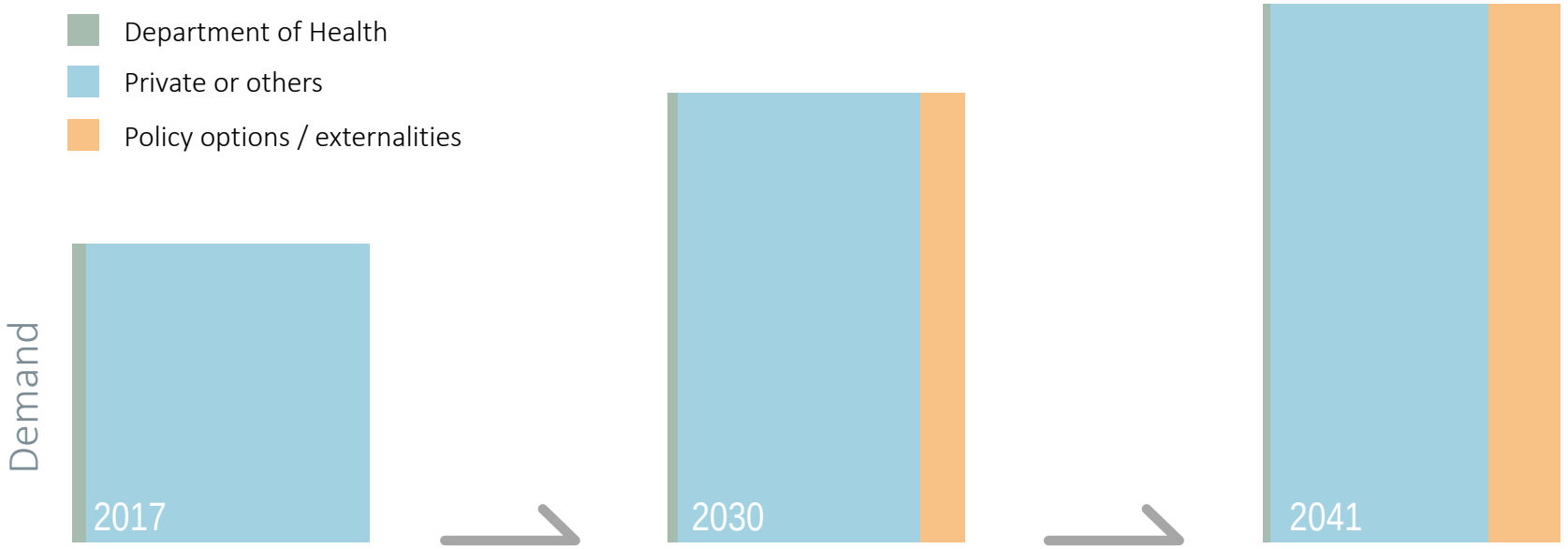


Dental hygienist



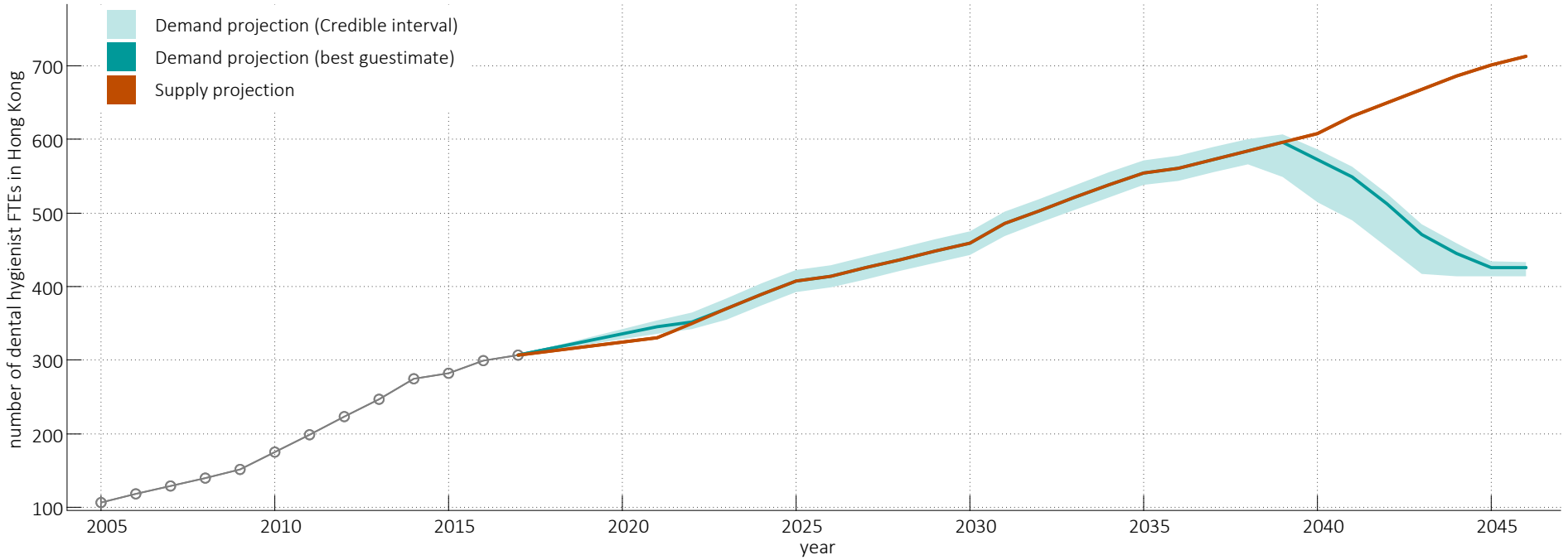
Policy options | Externalities

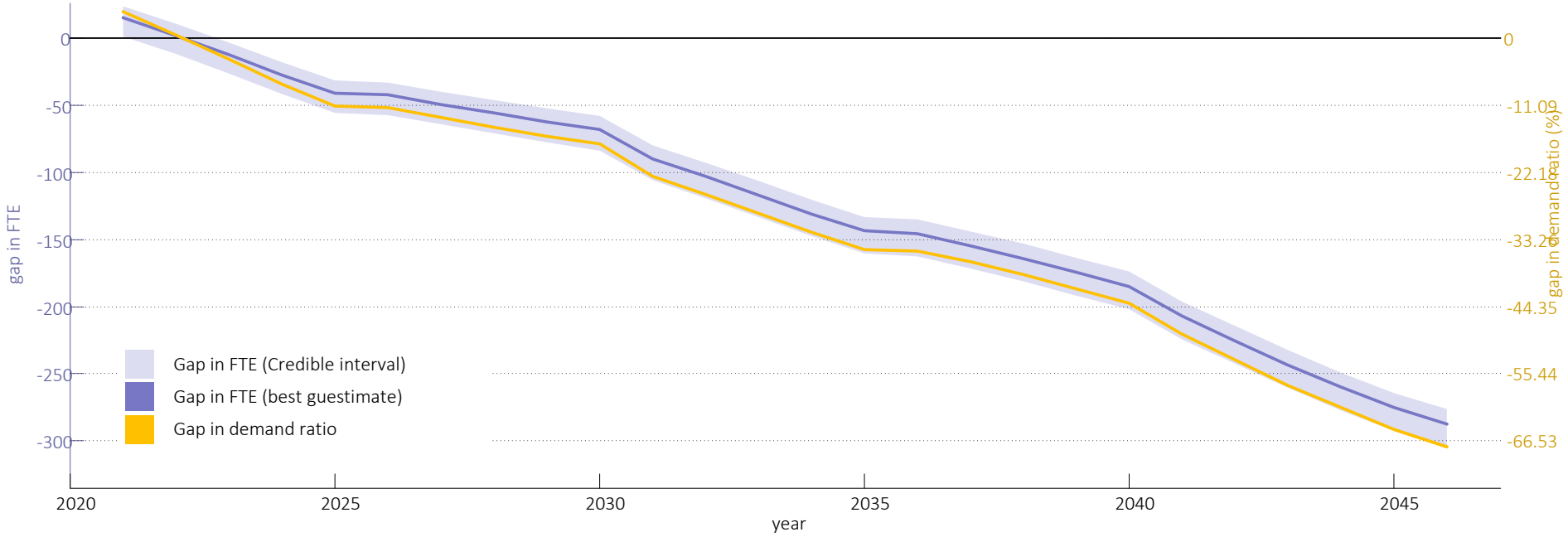
- Service substitution by dental hygienist



Dental hygienist

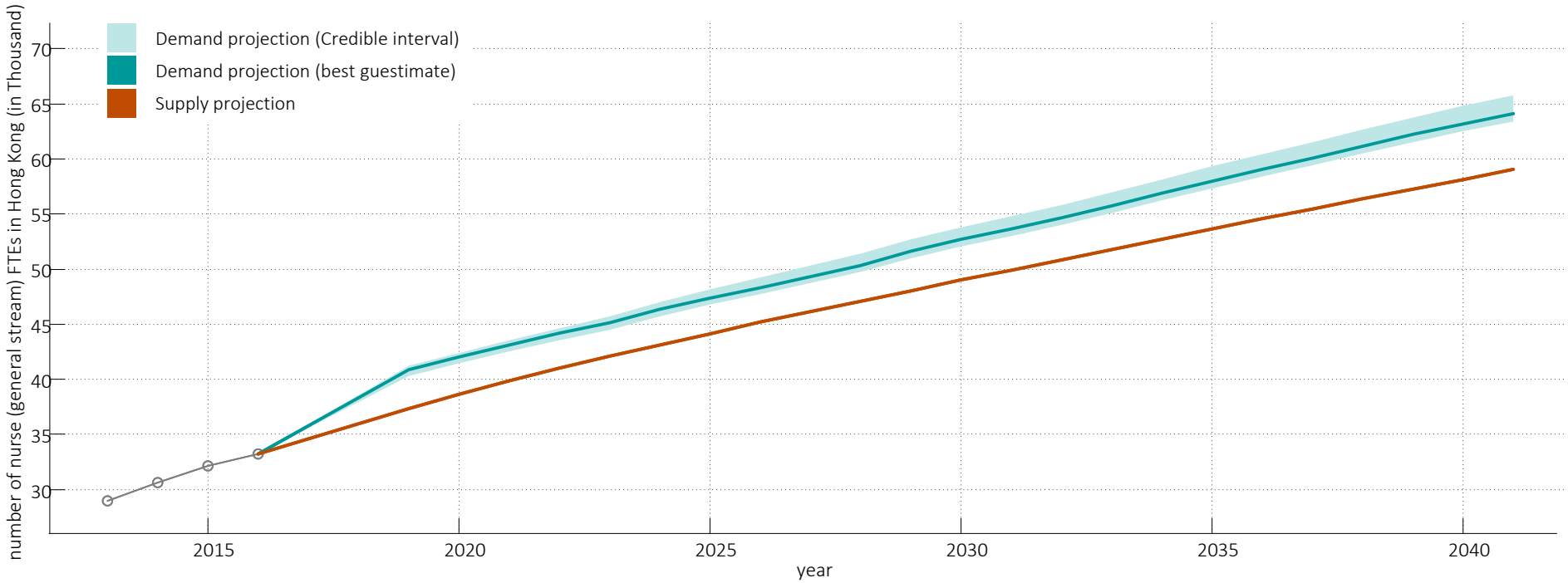
GAP ANALYSIS

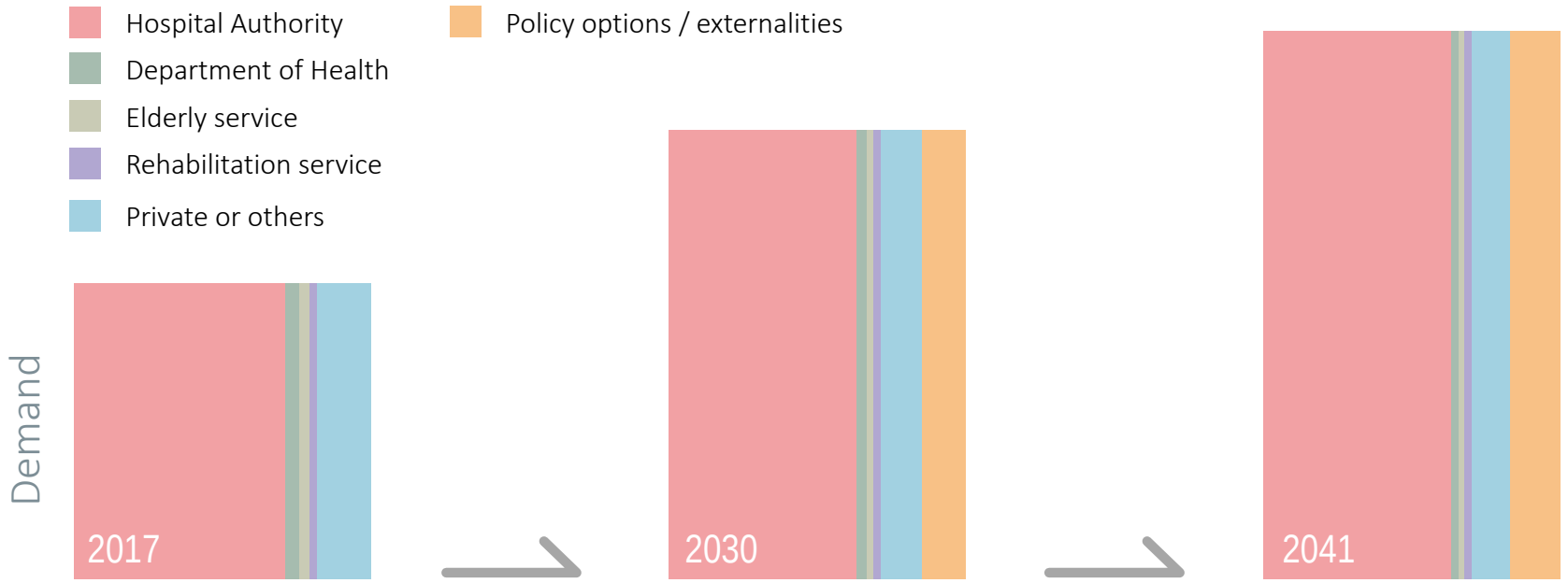




Nurse

General stream



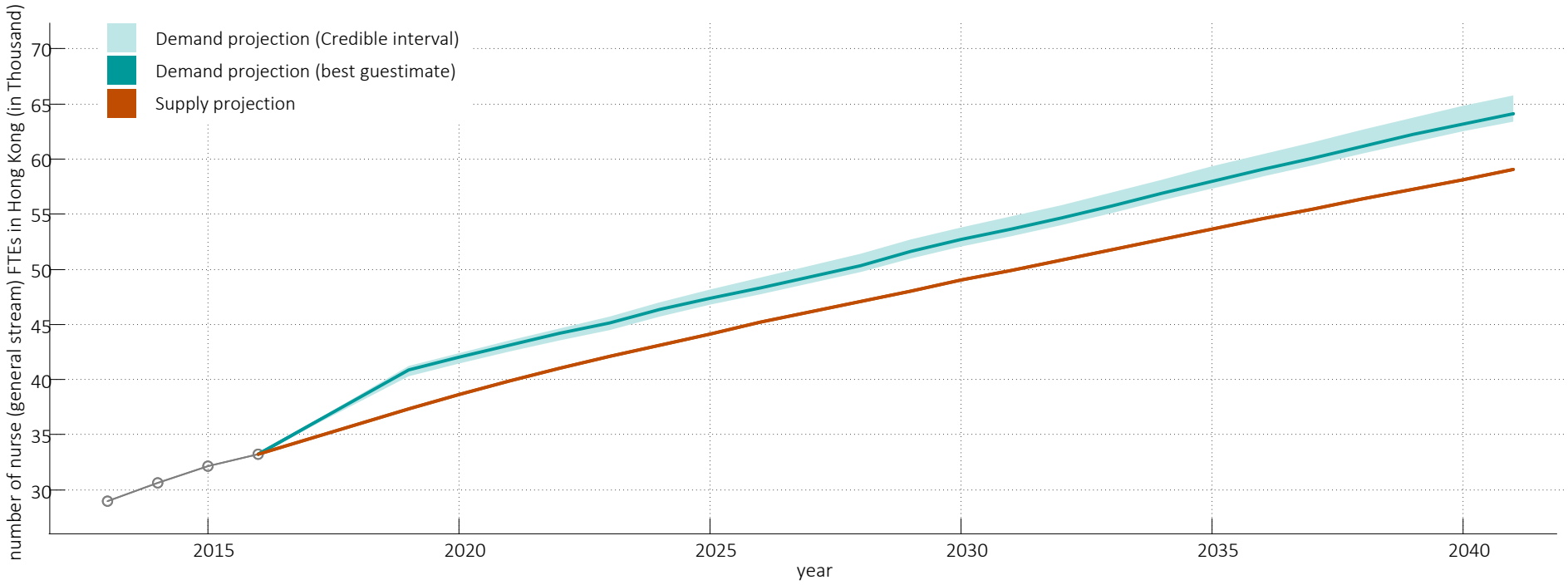


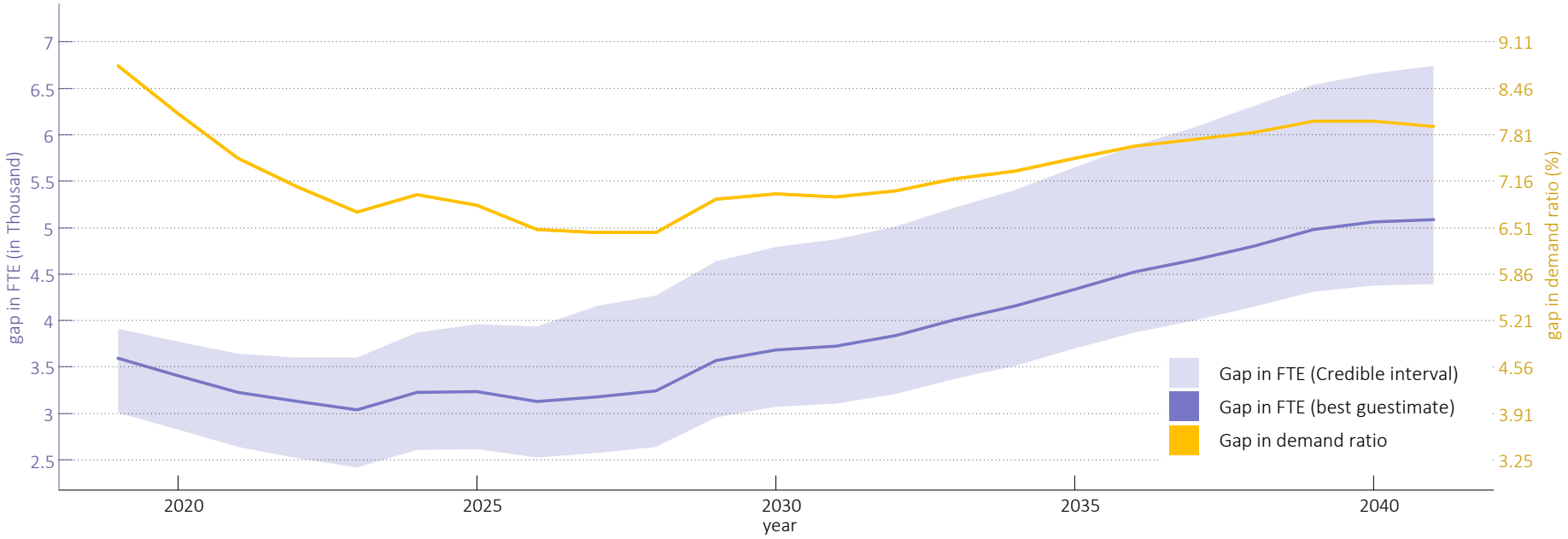
Policy options | Externalities

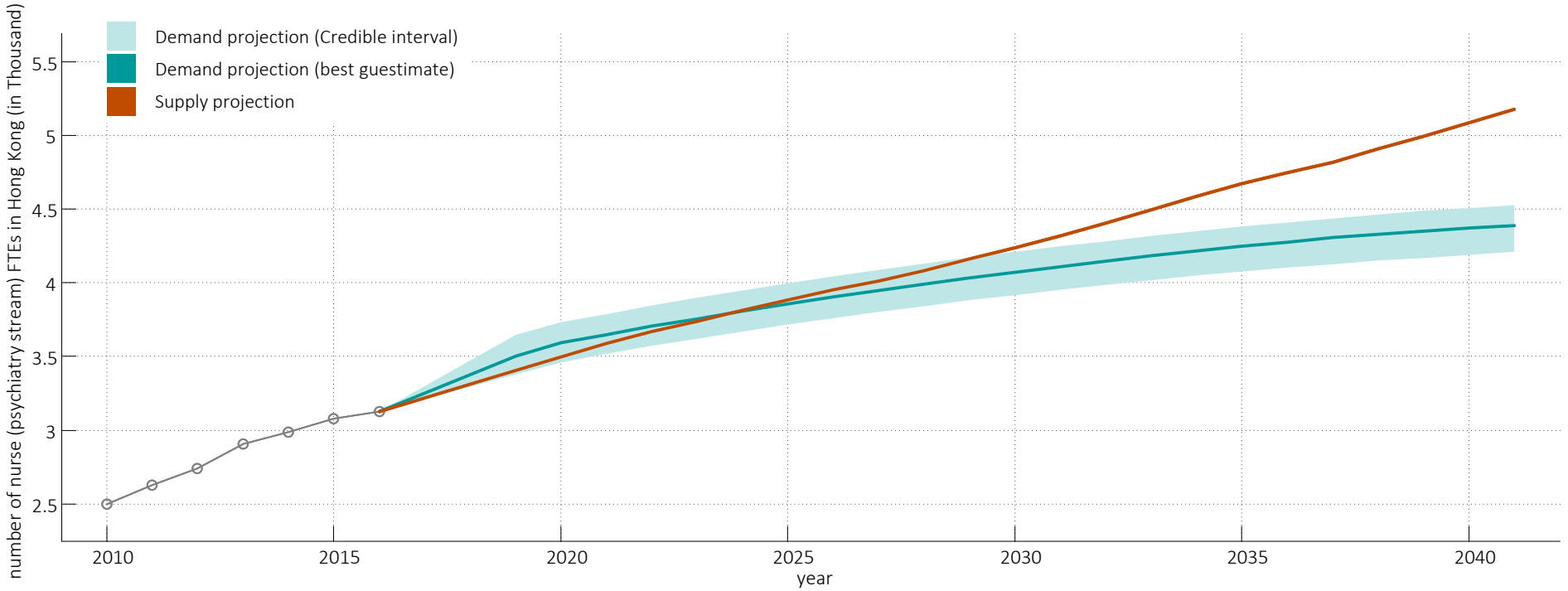
- Historical Manpower Shortage (Hospital Authority)
- Historical Manpower Shortage (Department of Health)
- New Private Hospitals
- Voluntary Health Insurance Scheme
- Planned Elderly Service (Social Welfare Department)
- Planned Rehabilitation Service (Social Welfare Department)
- School Nursing Service Enhancement (Education Bureau)
- District Health Centres
- Self-financing Service (NGO)
- Elderly service enhancement

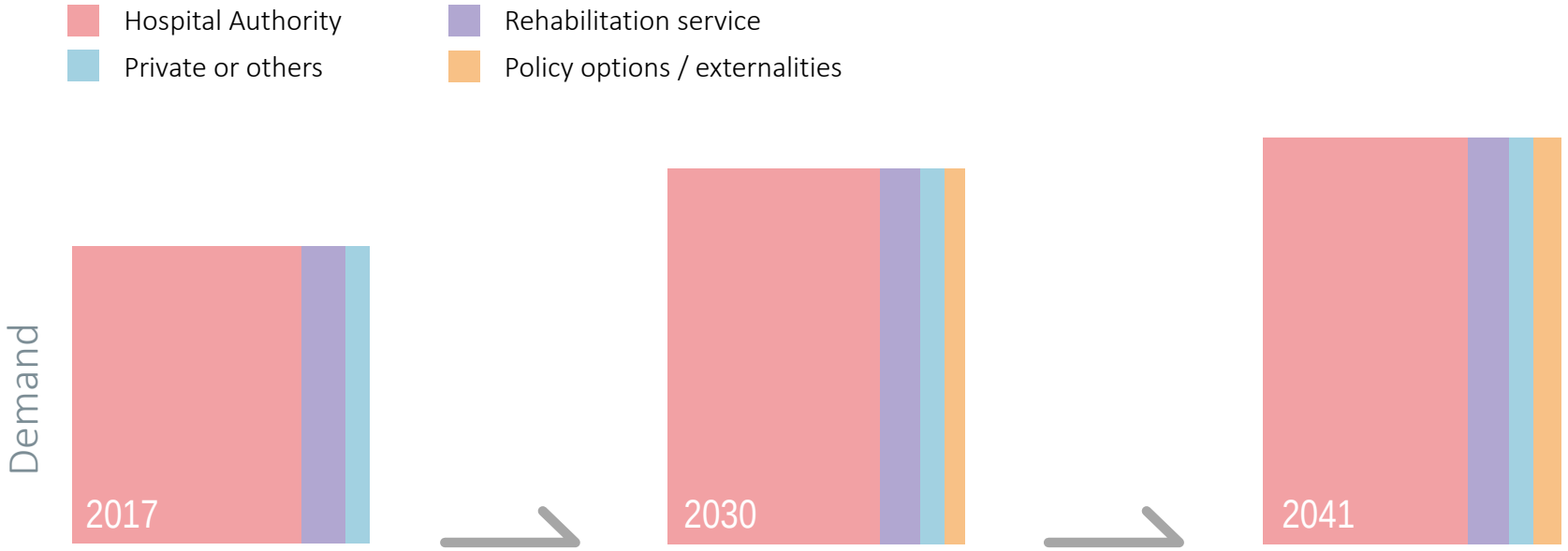
Nurse
General stream

GAP ANALYSIS









Nurse

Psychiatric stream

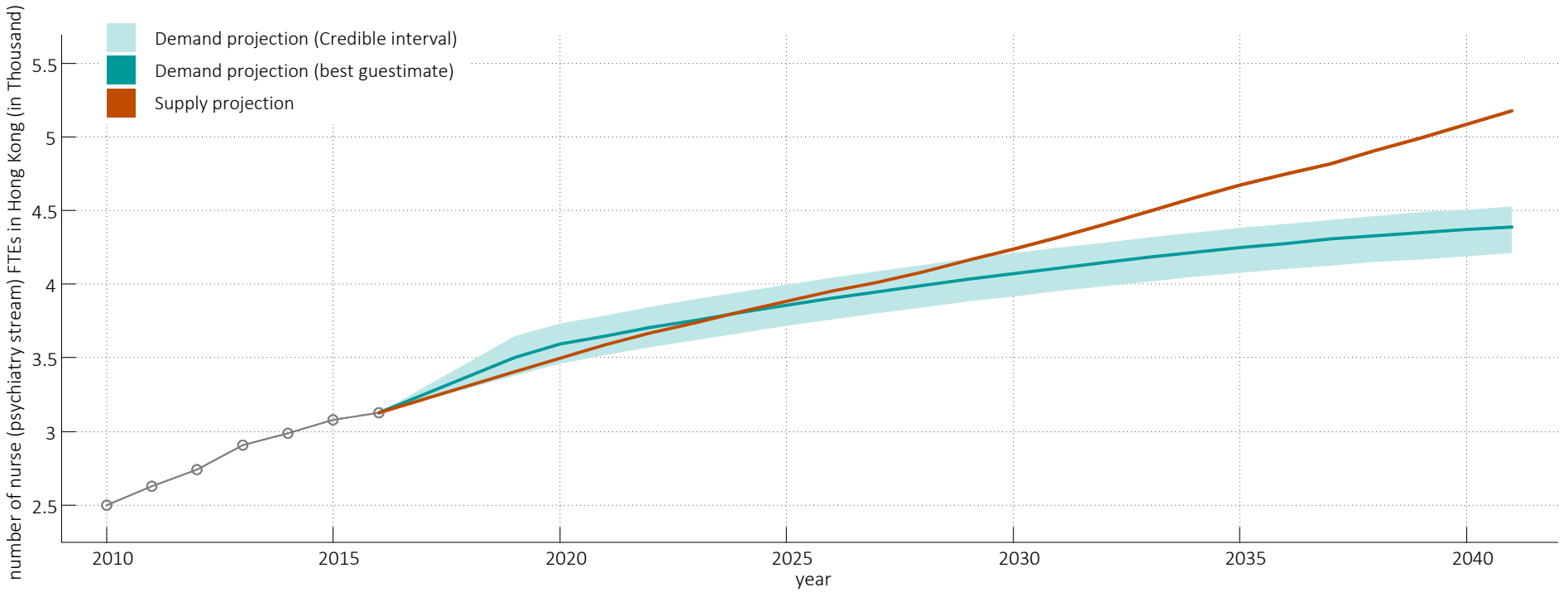
Policy options | Externalities

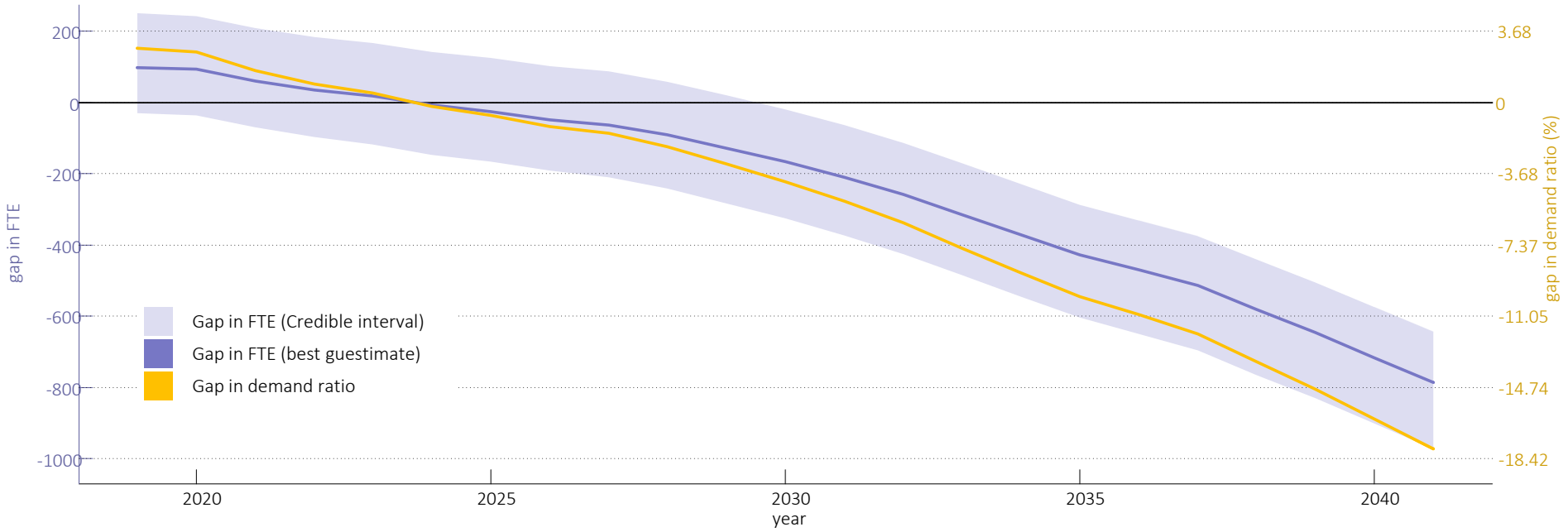
- Student Mental Support Scheme
- Self-financing Service (NGO)

Nurse

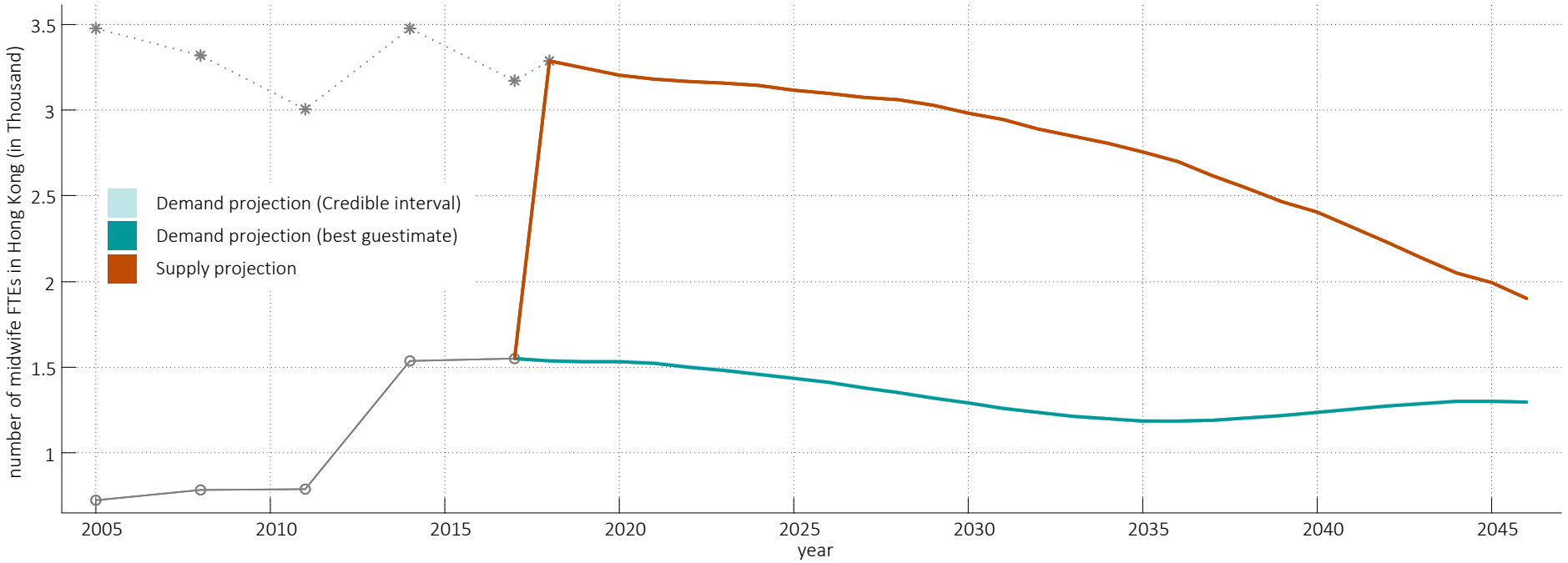
Psychiatric stream

GAP ANALYSIS





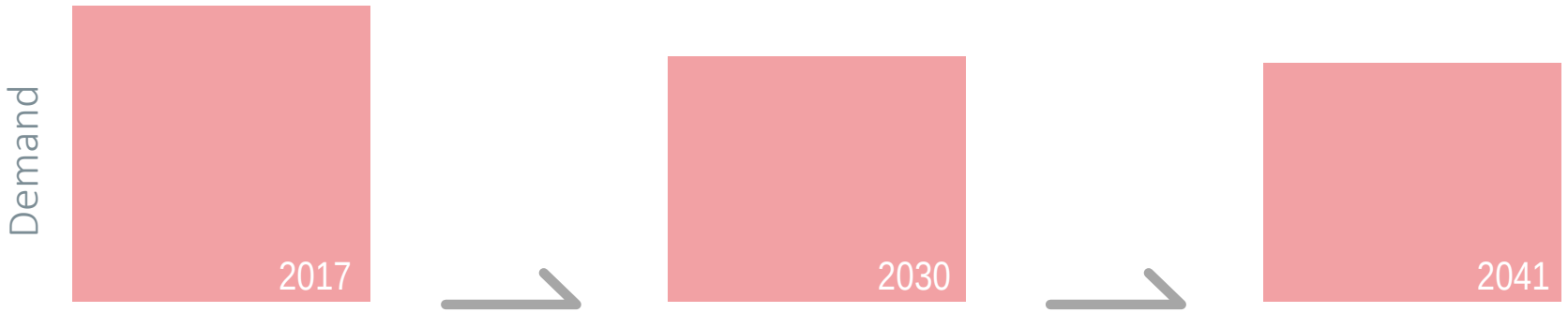
Midwife



- No

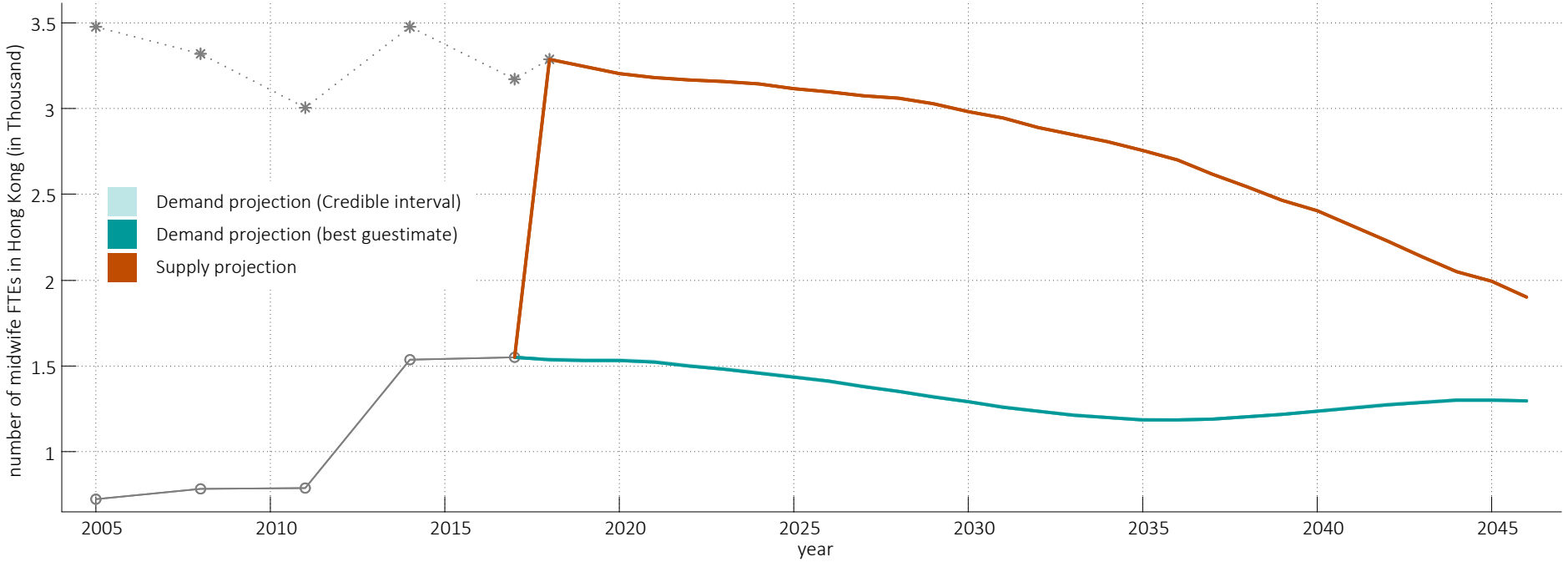
Policy options / externalities

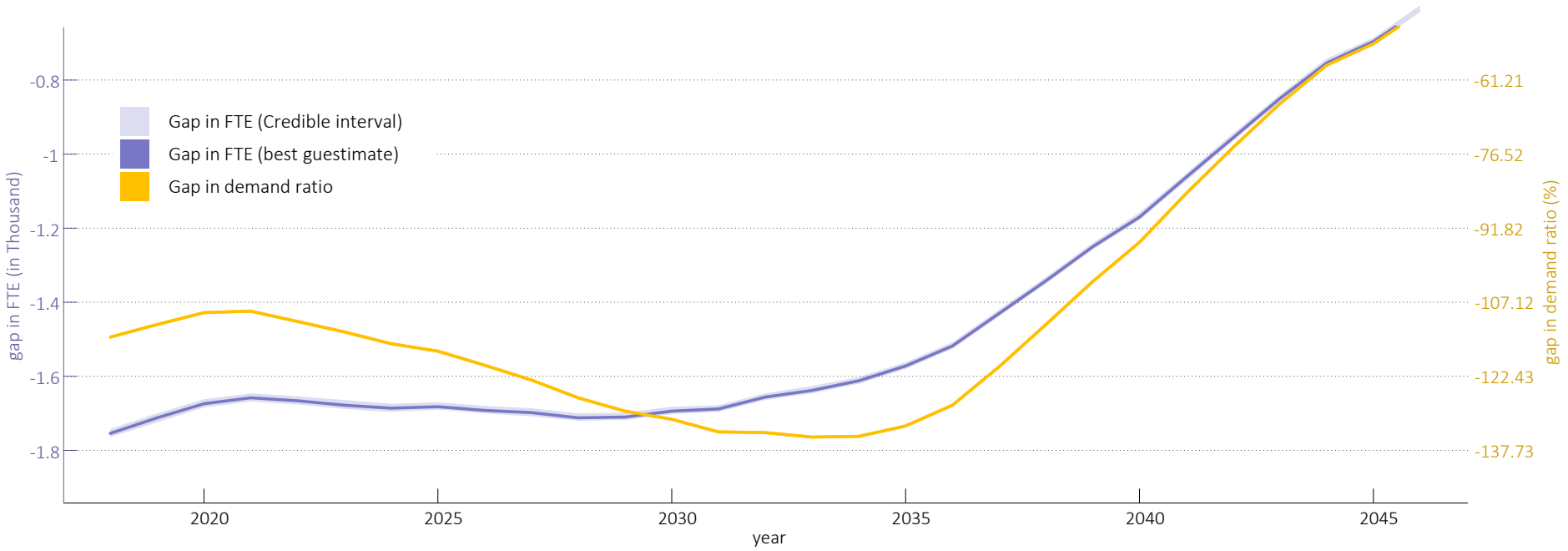
Hong Kong
(both public and private)

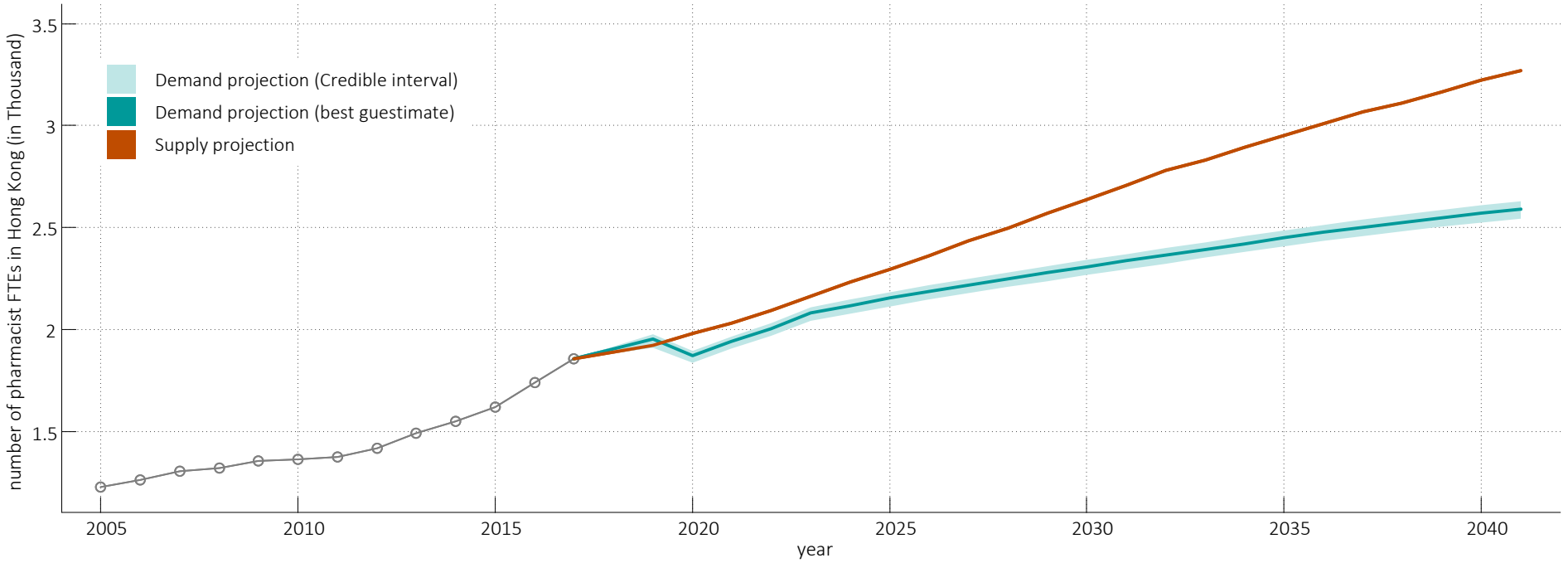


Midwife

GAP ANALYSIS



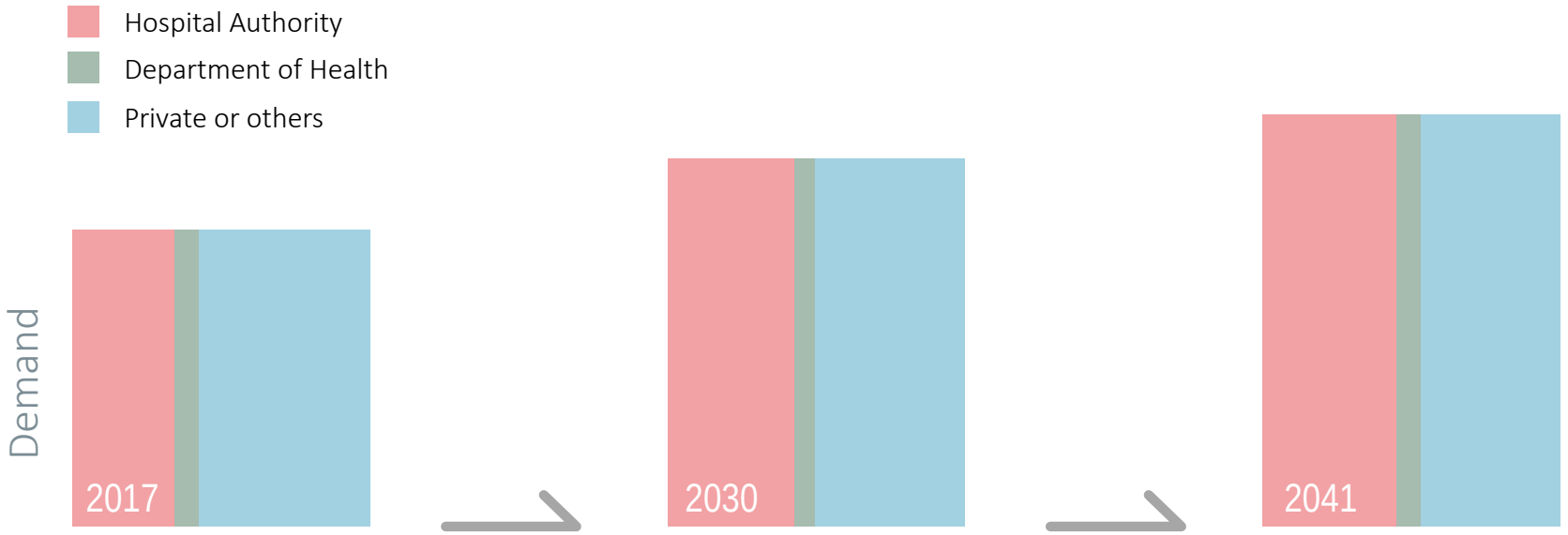




Pharmacist

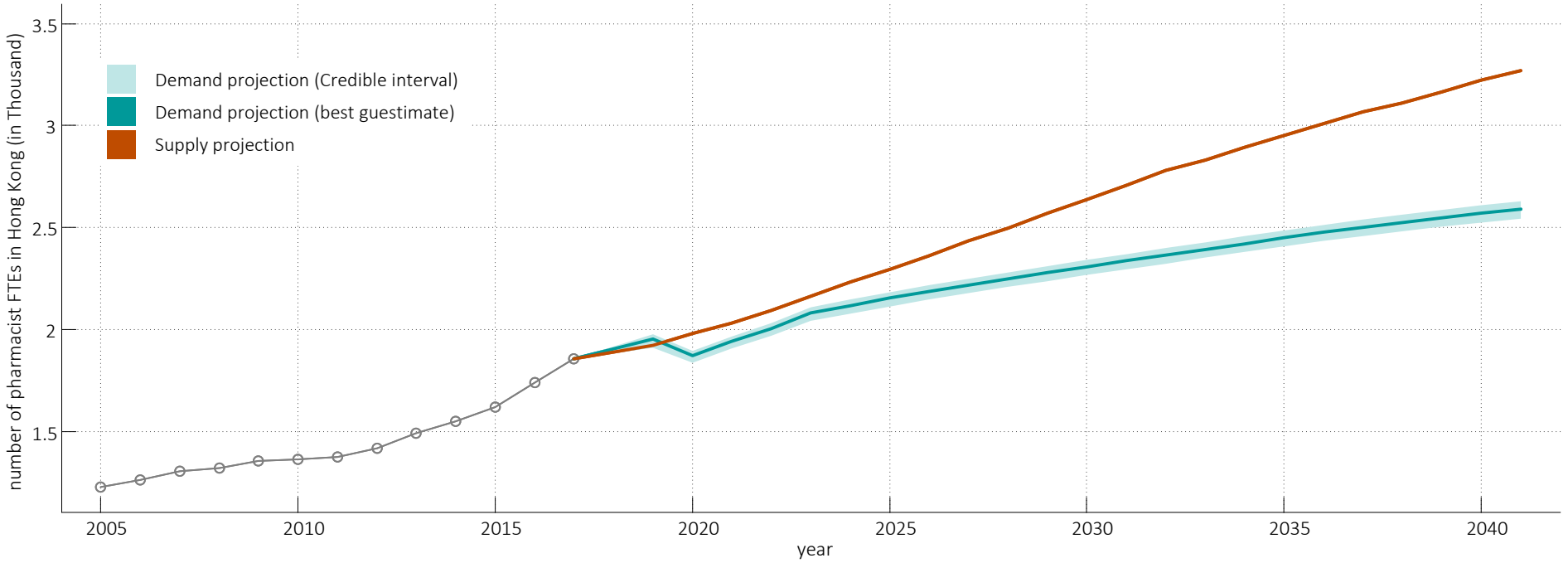
- No

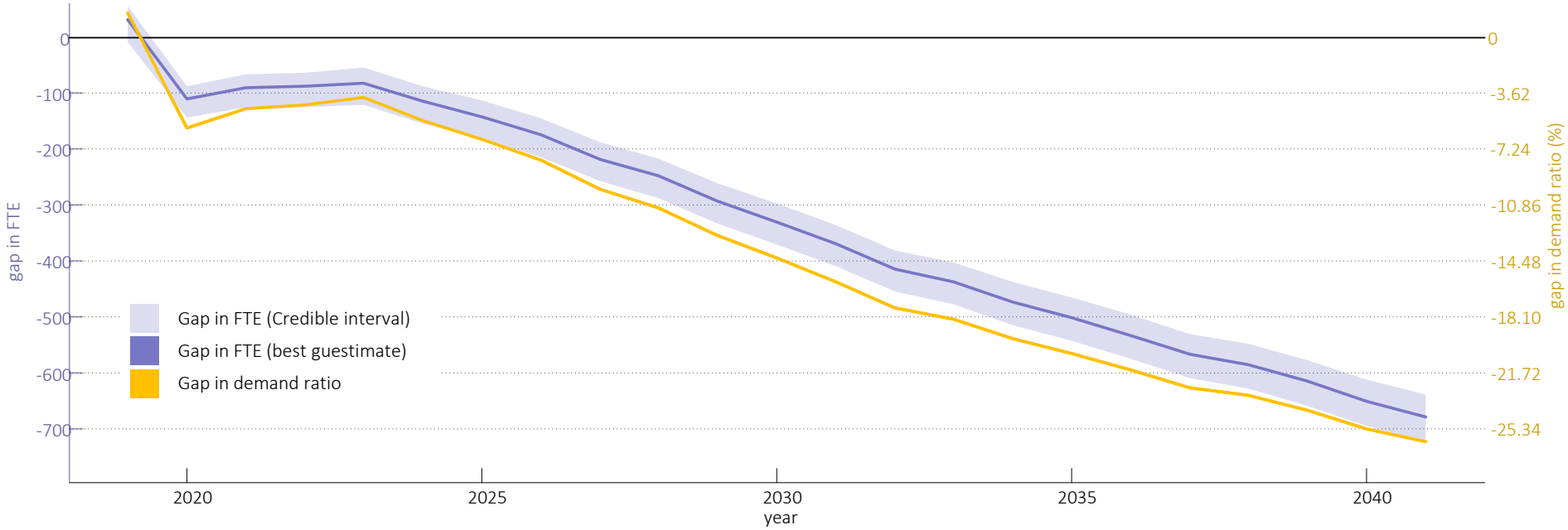
Policy options / externalities



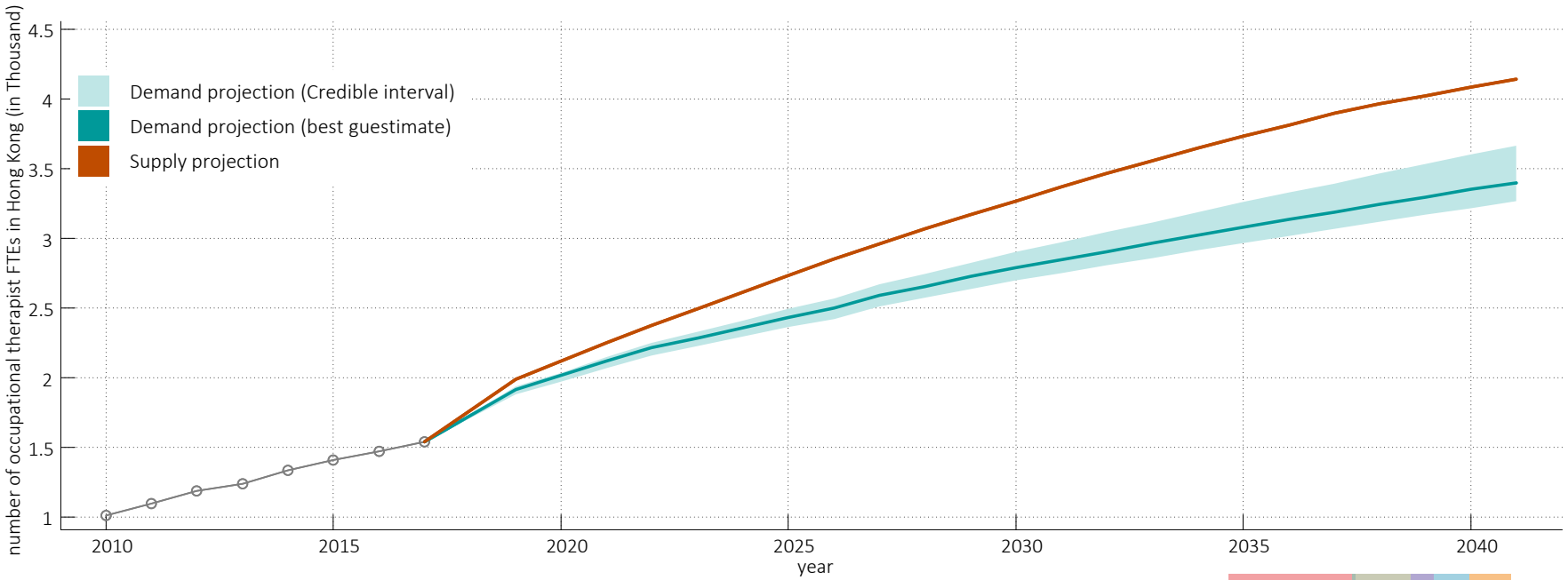
Pharmacist

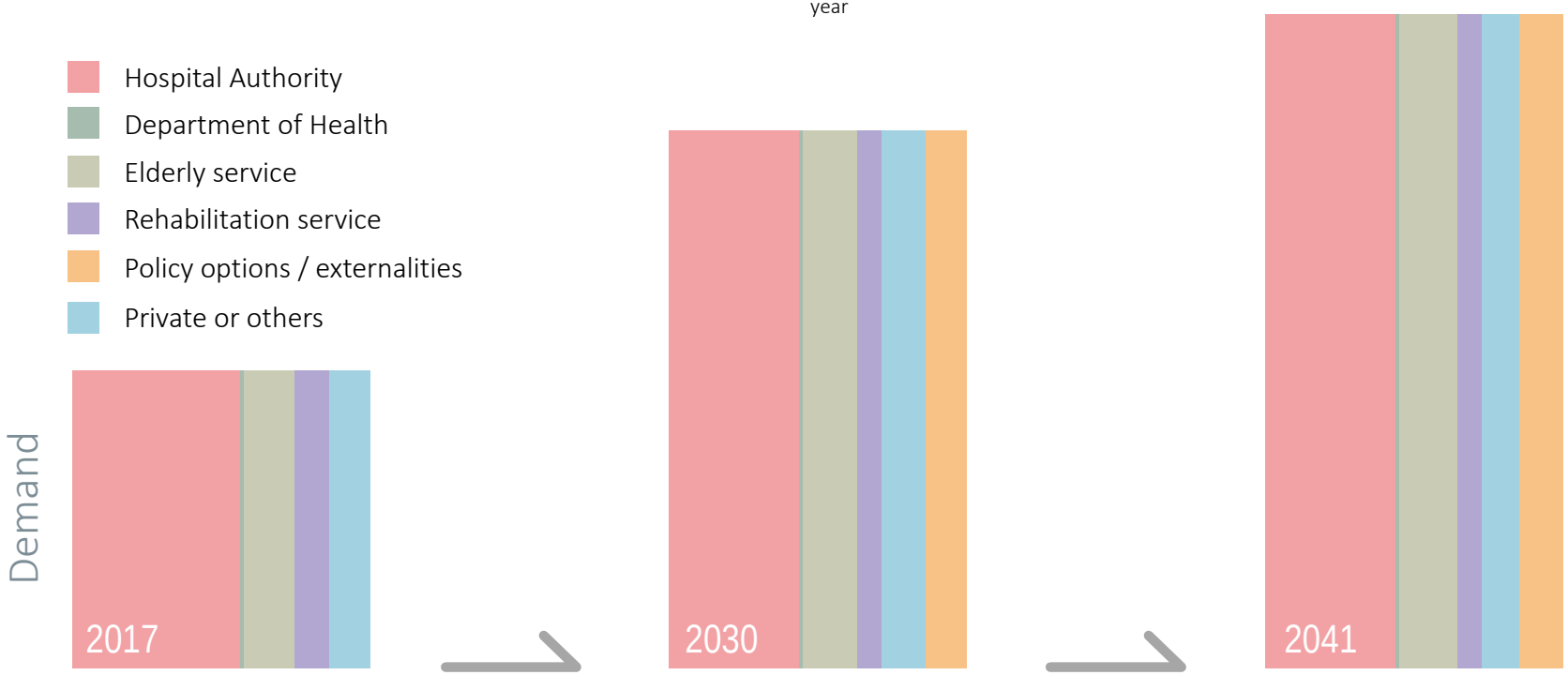
GAP ANALYSIS





Occupational therapist



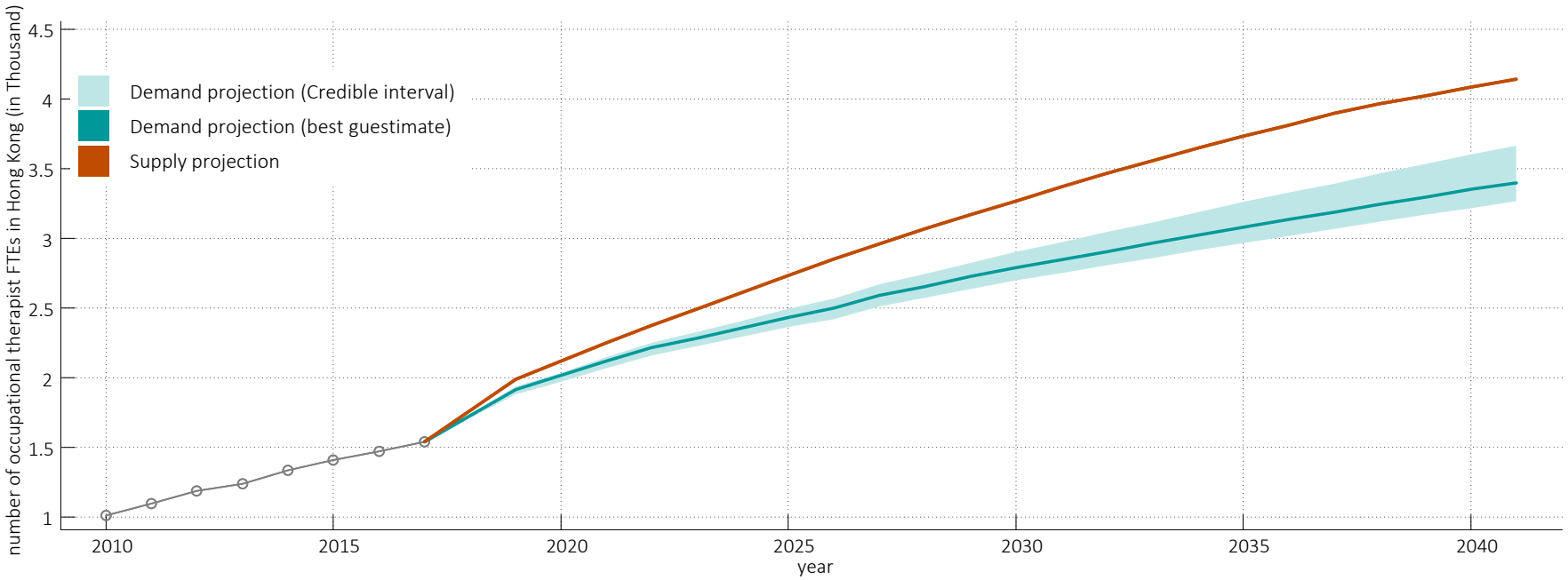


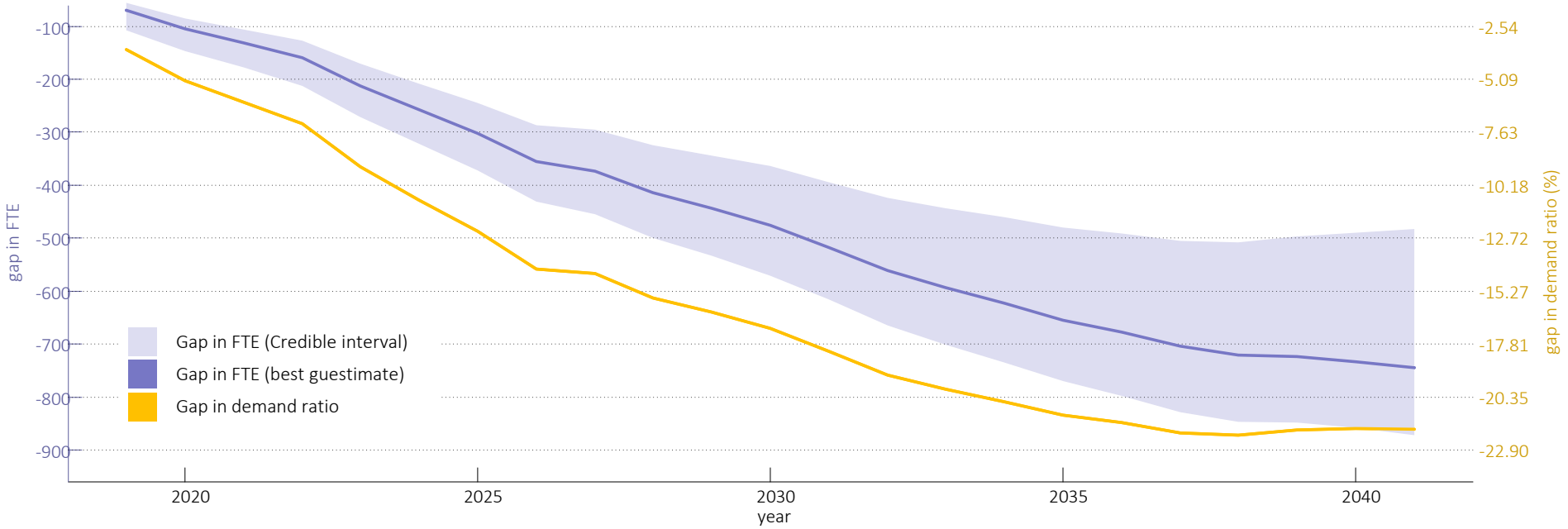
Policy options | Externalities

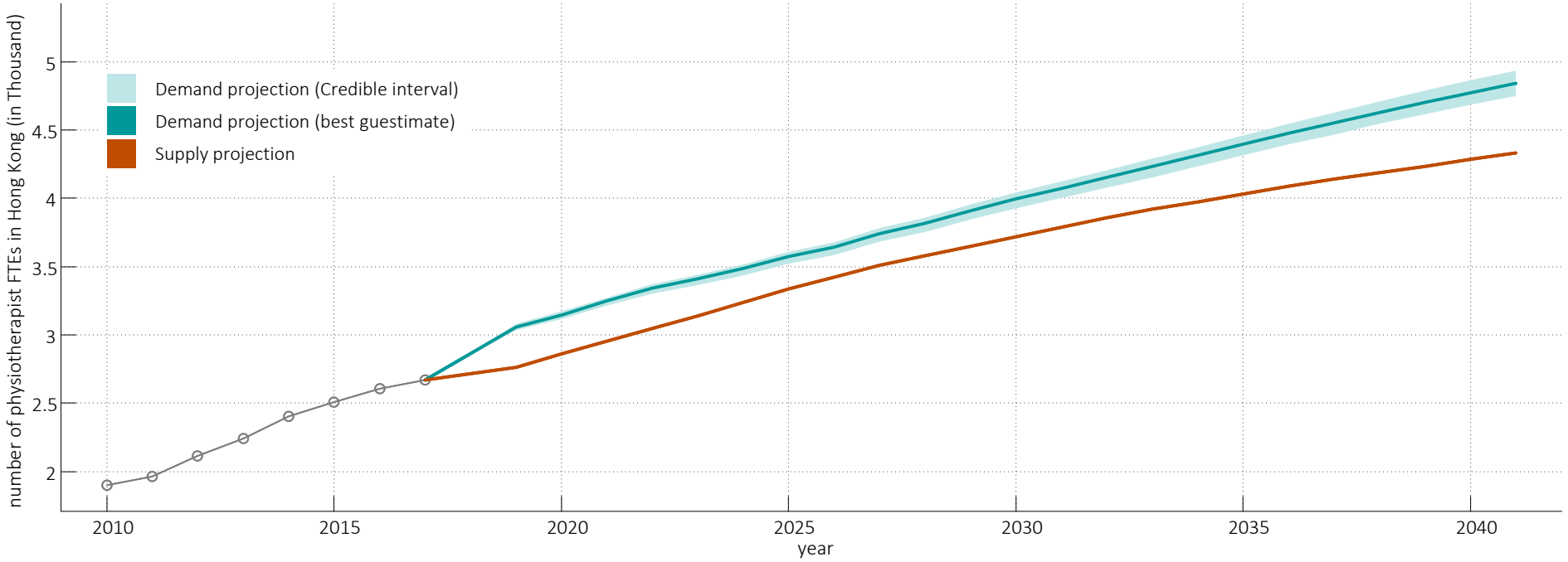
- Planned Elderly Service (Social Welfare Department)
- Planned Rehabilitation Service (Social Welfare Department)
- Service Enhancement (Hospital Authority)
- District Health Centres
- Elderly service enhancement

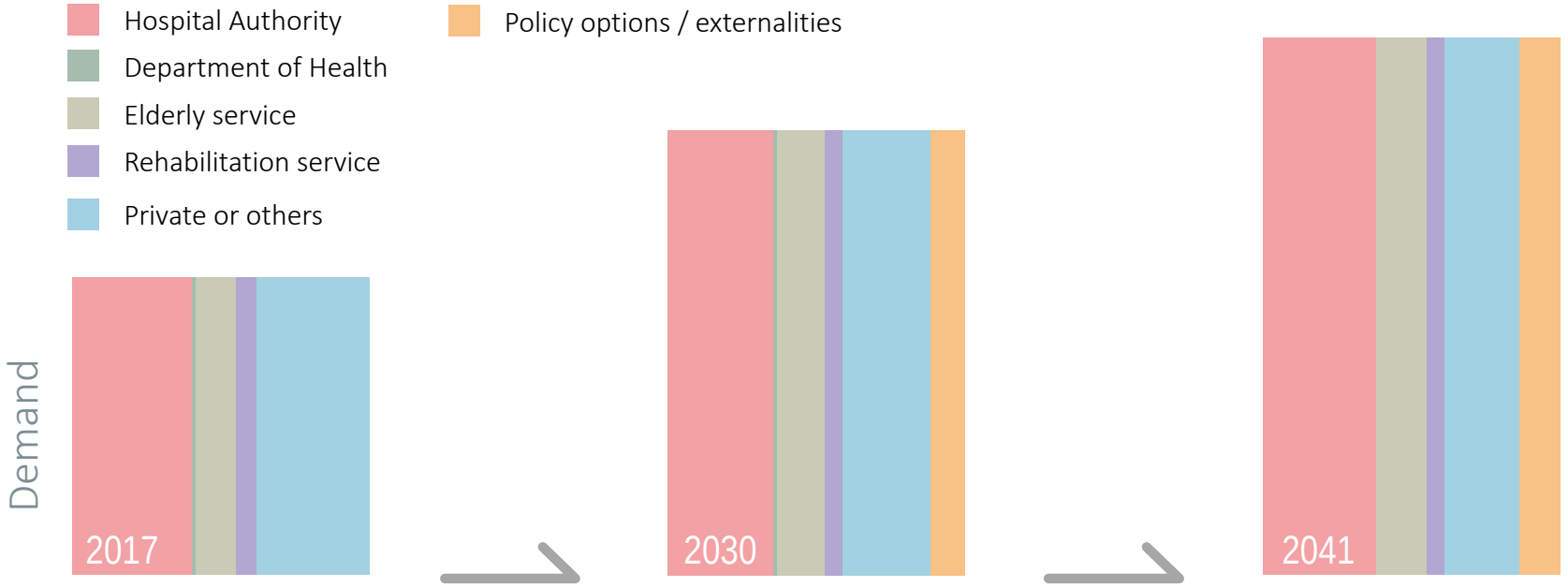
Occupational Therapist

Gap Analysis









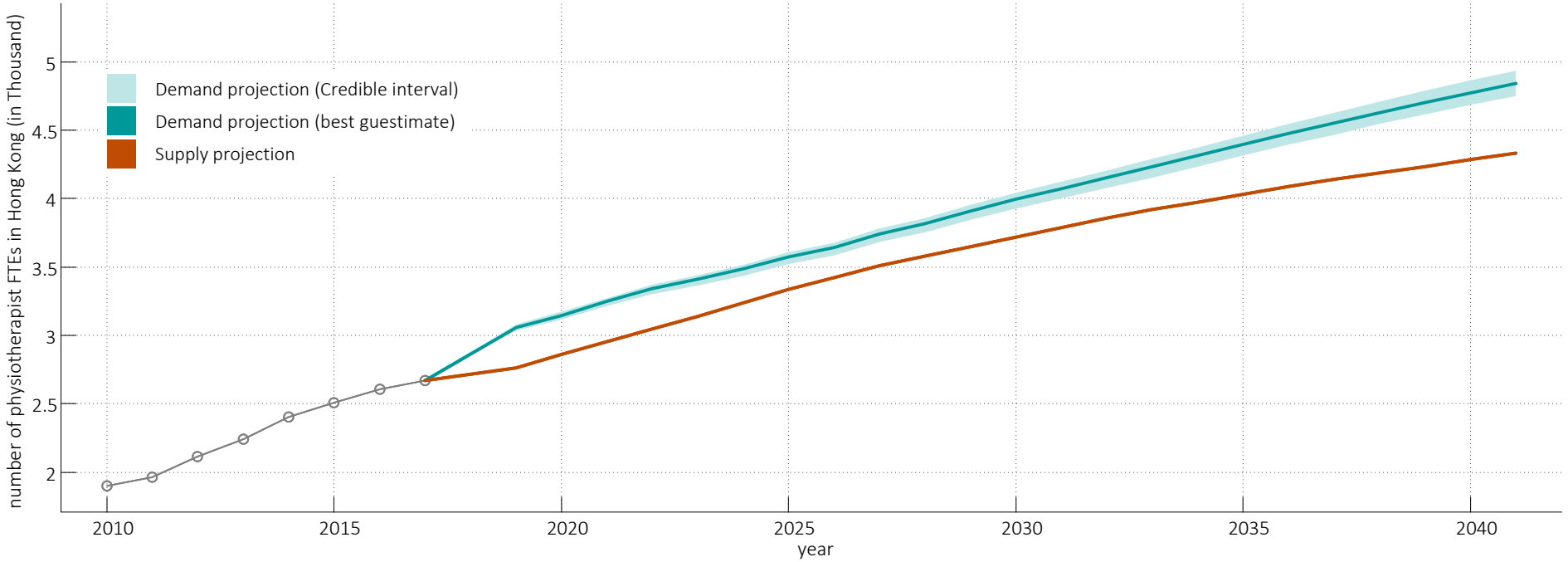
PHYSIOTHERAPIST

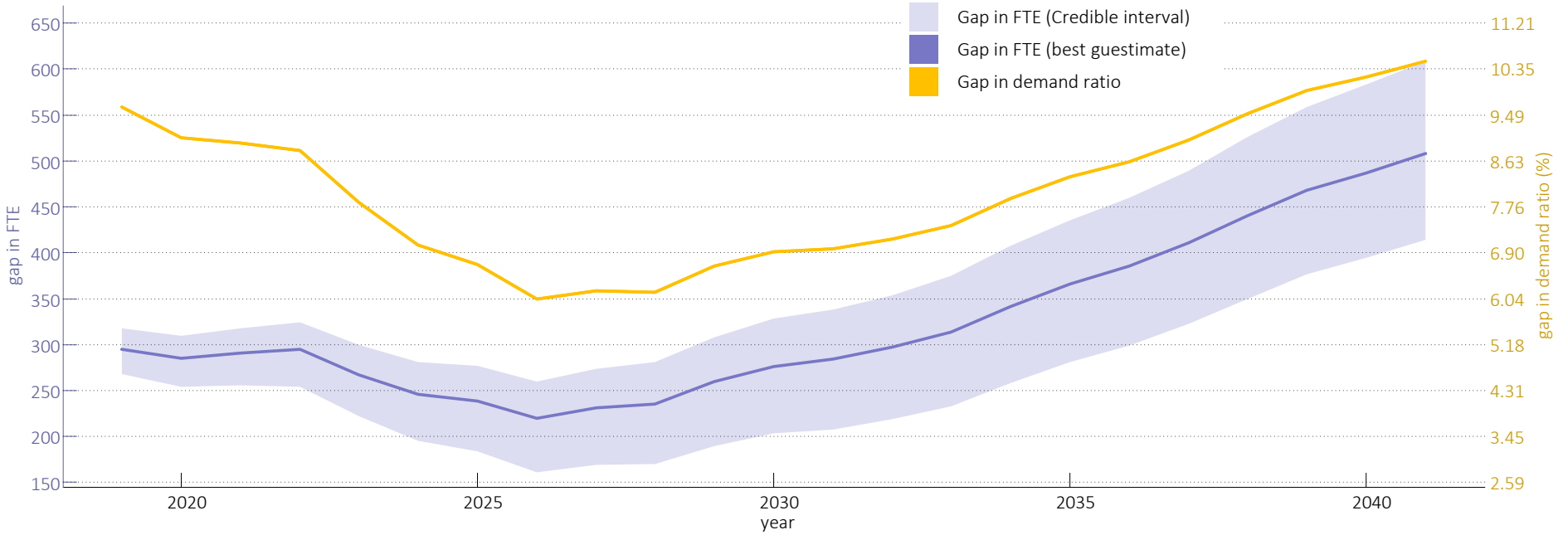
Policy options | Externalities

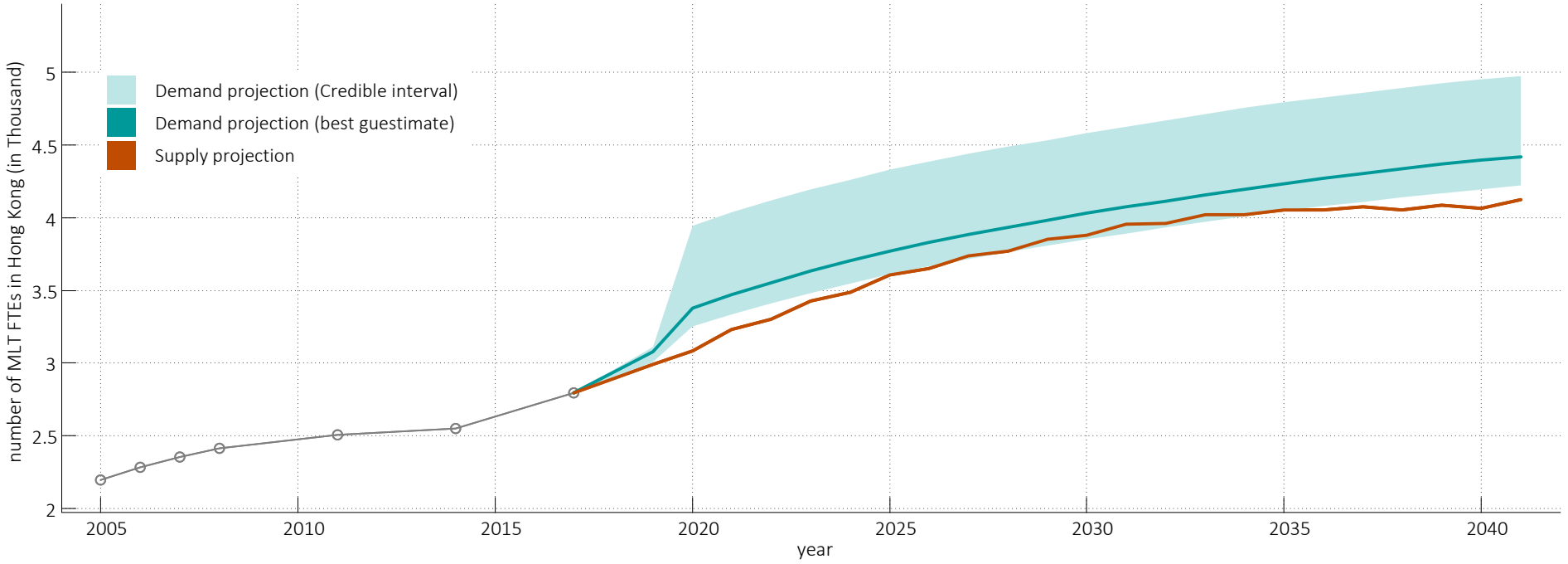
- Planned Elderly Service
  (Social Welfare Department)
- Planned Rehabilitation Service
  (Social Welfare Department)
- Service Enhancement
  (Hospital Authority)
- District Health Centres
- Elderly service enhancement

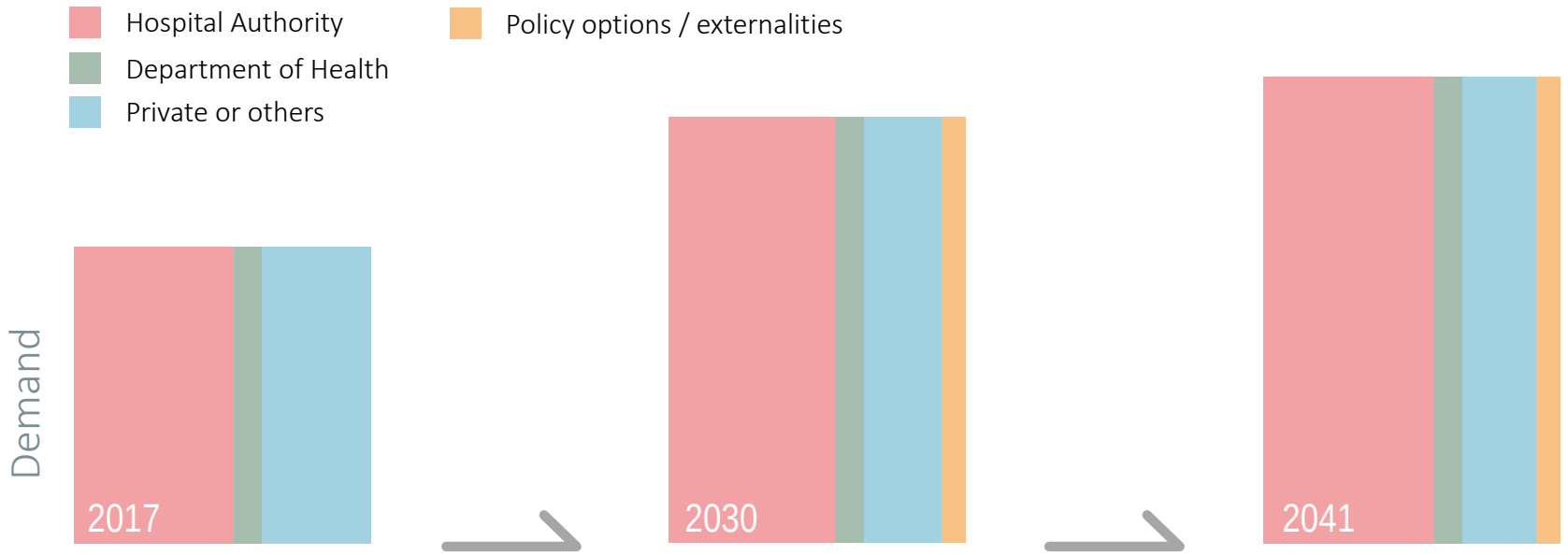
PHYSIOTHERAPIST

GAP ANALYSIS









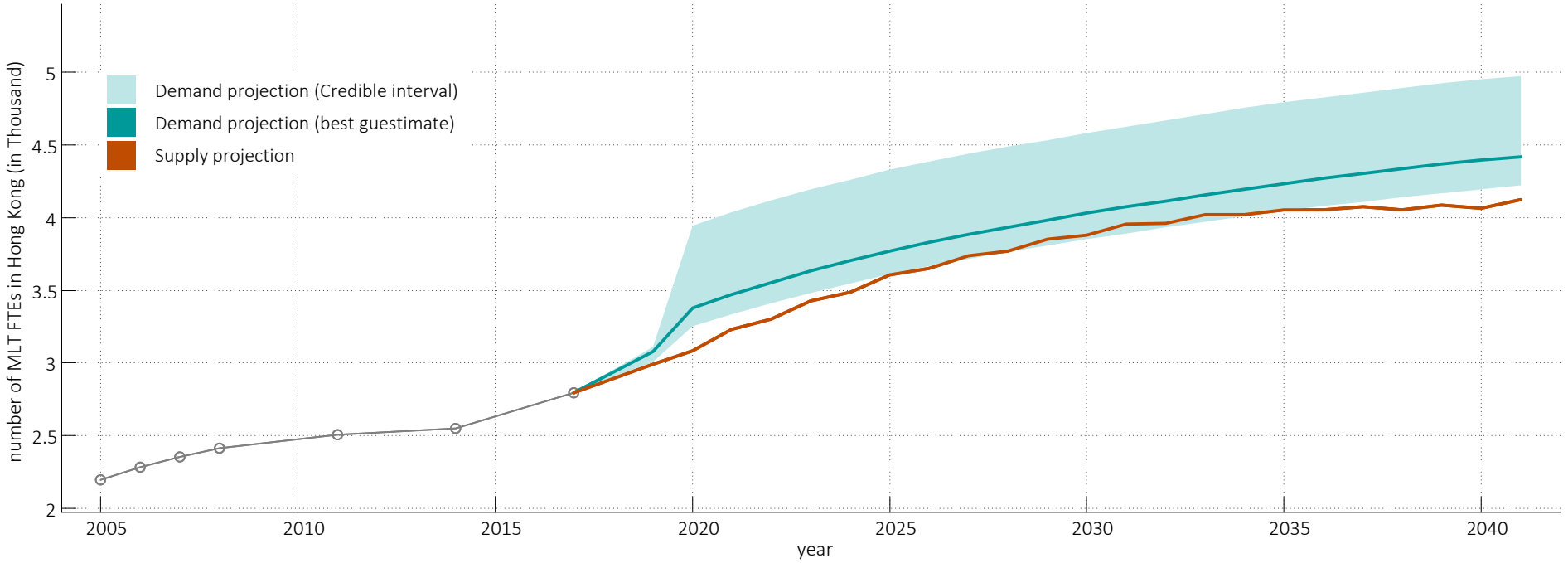
MEDICAL LABORATORY TECHNOLOGIST

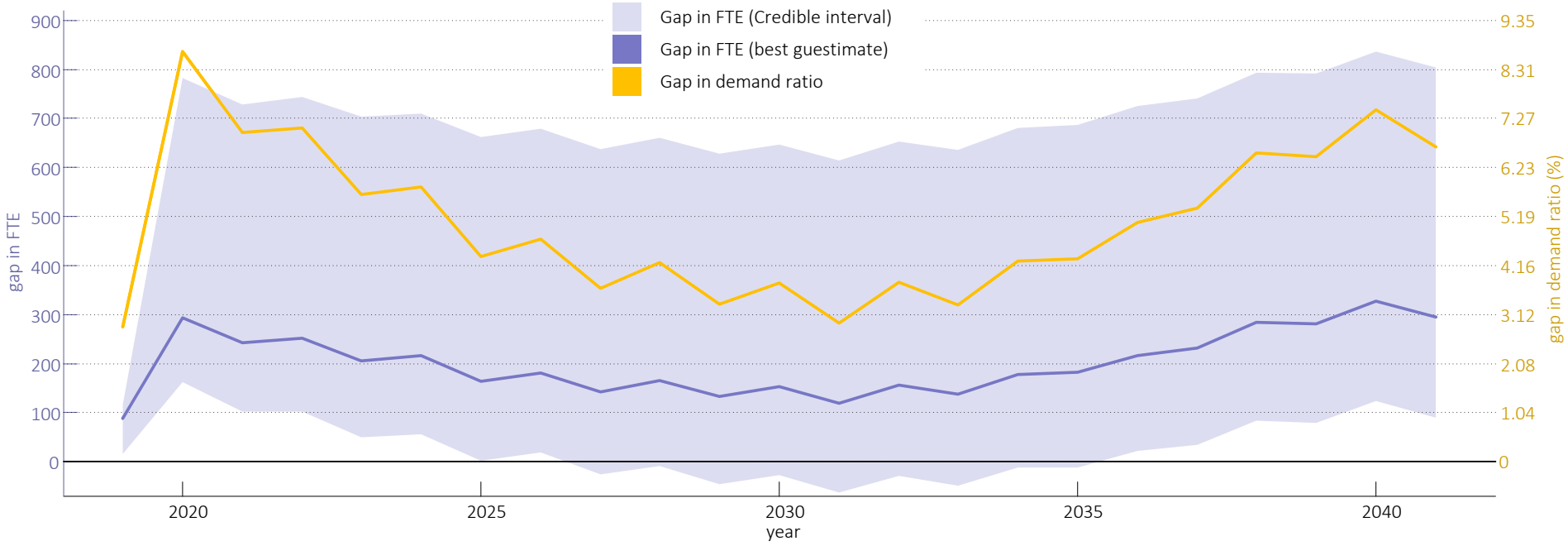
Policy options | Externalities

- Additional demand induced by COVID-19

MEDICAL LABORATORY TECHNOLOGIST

GAP ANALYSIS

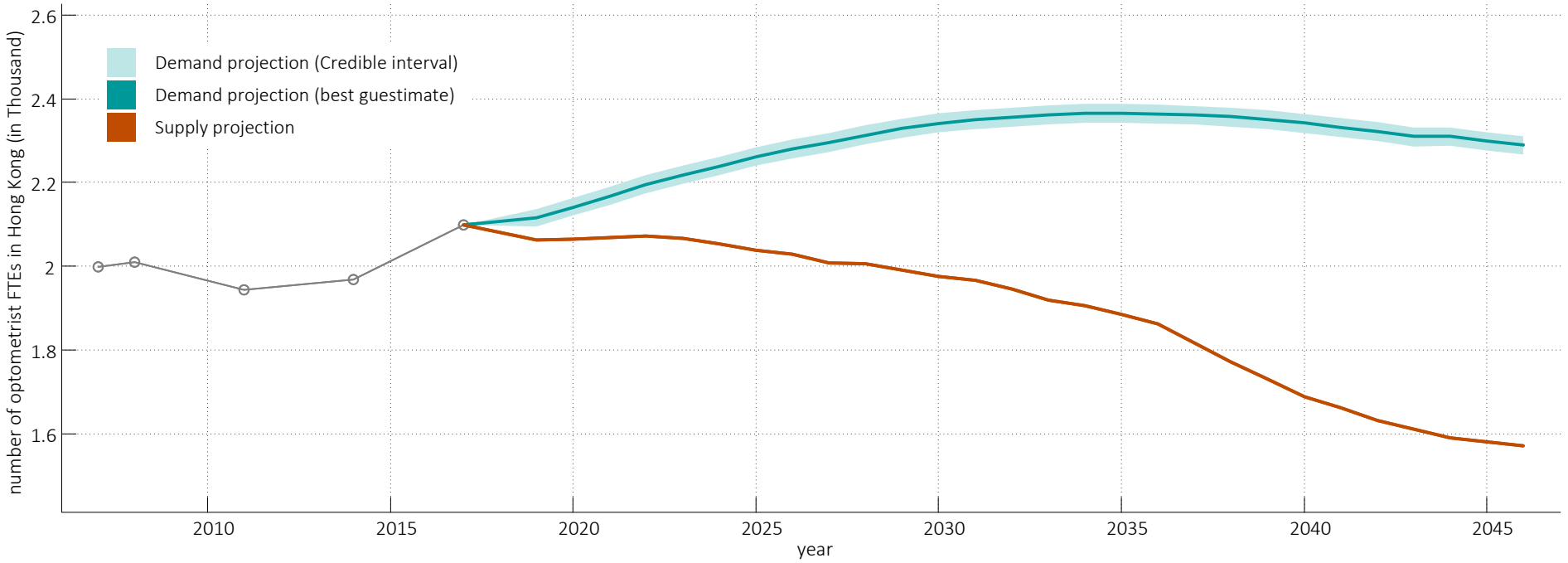


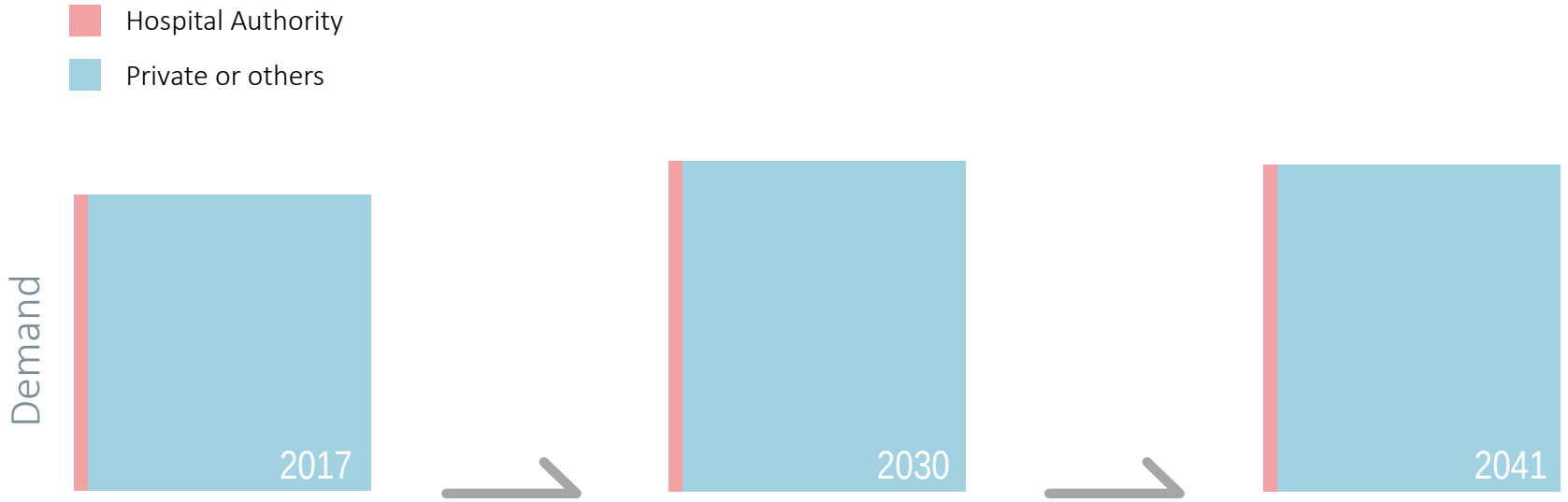


Optometrist

- No

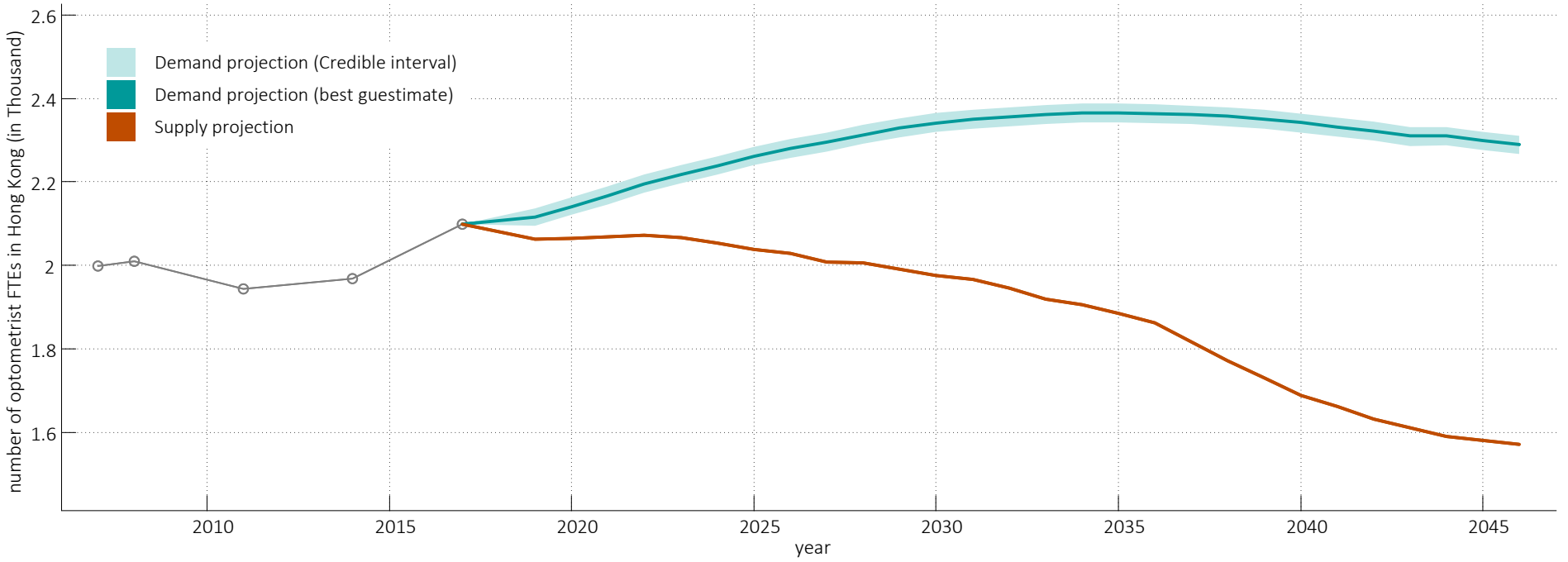
Policy options / externalities

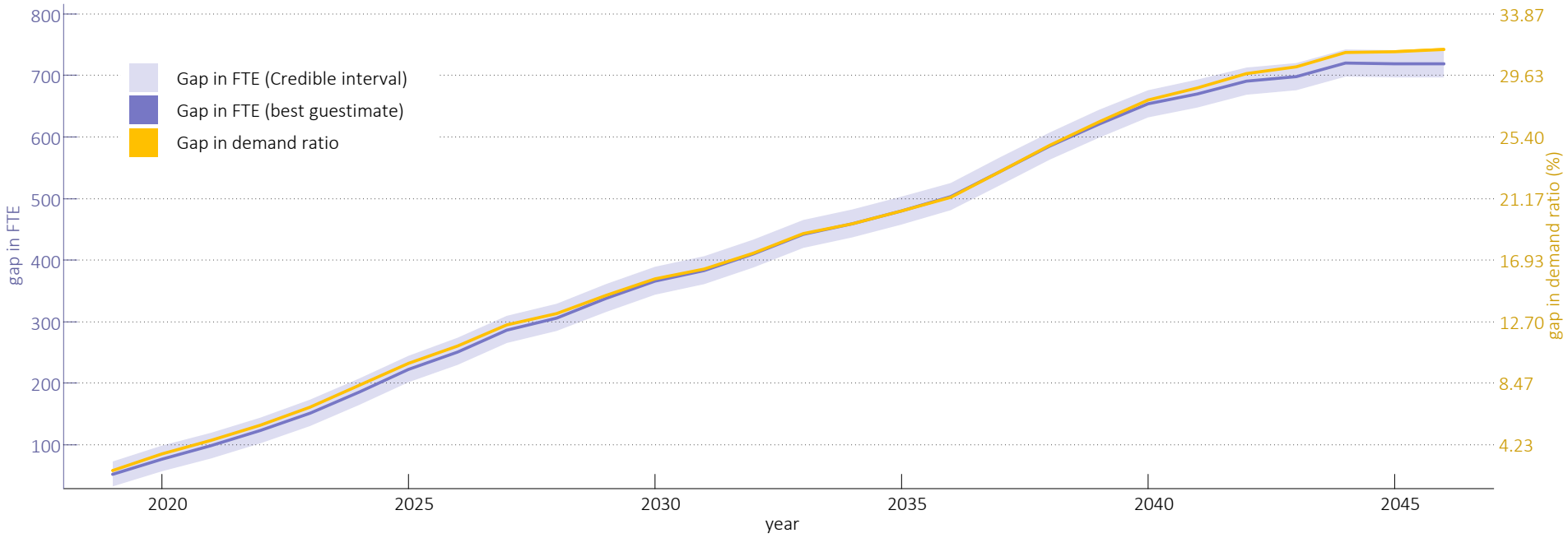




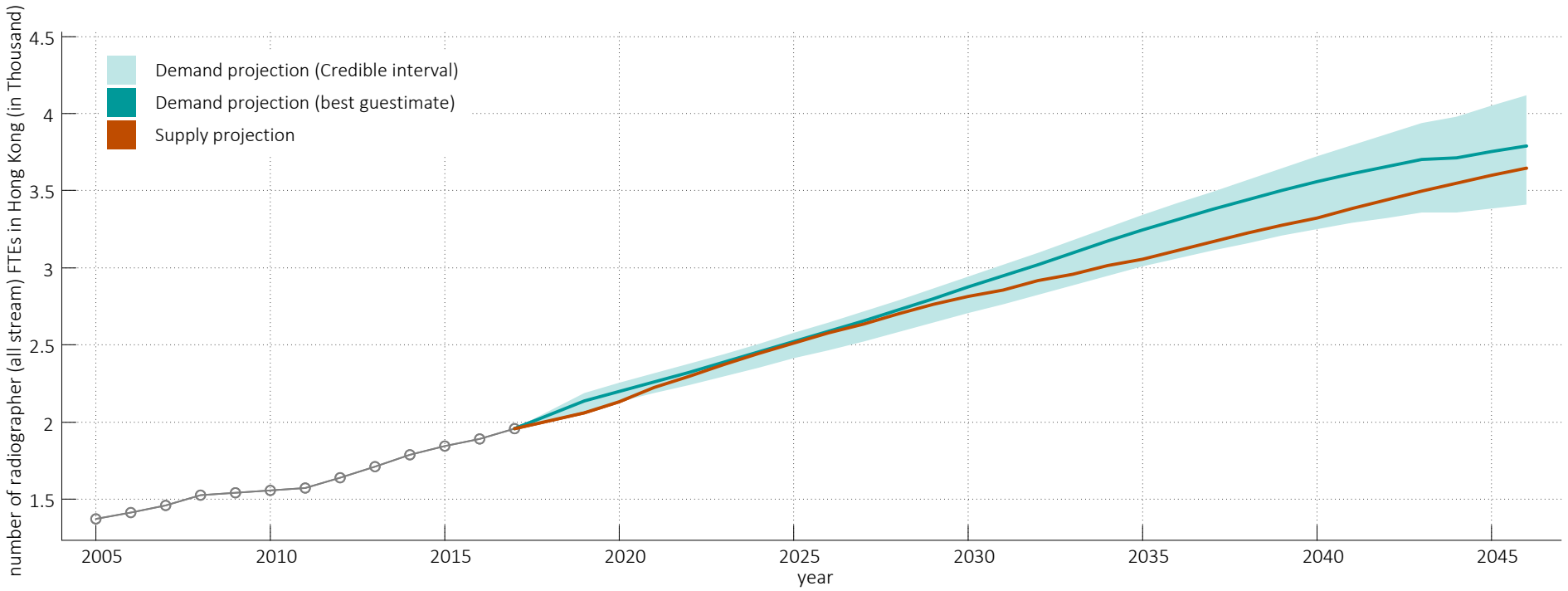
Optometrist

Gap analysis

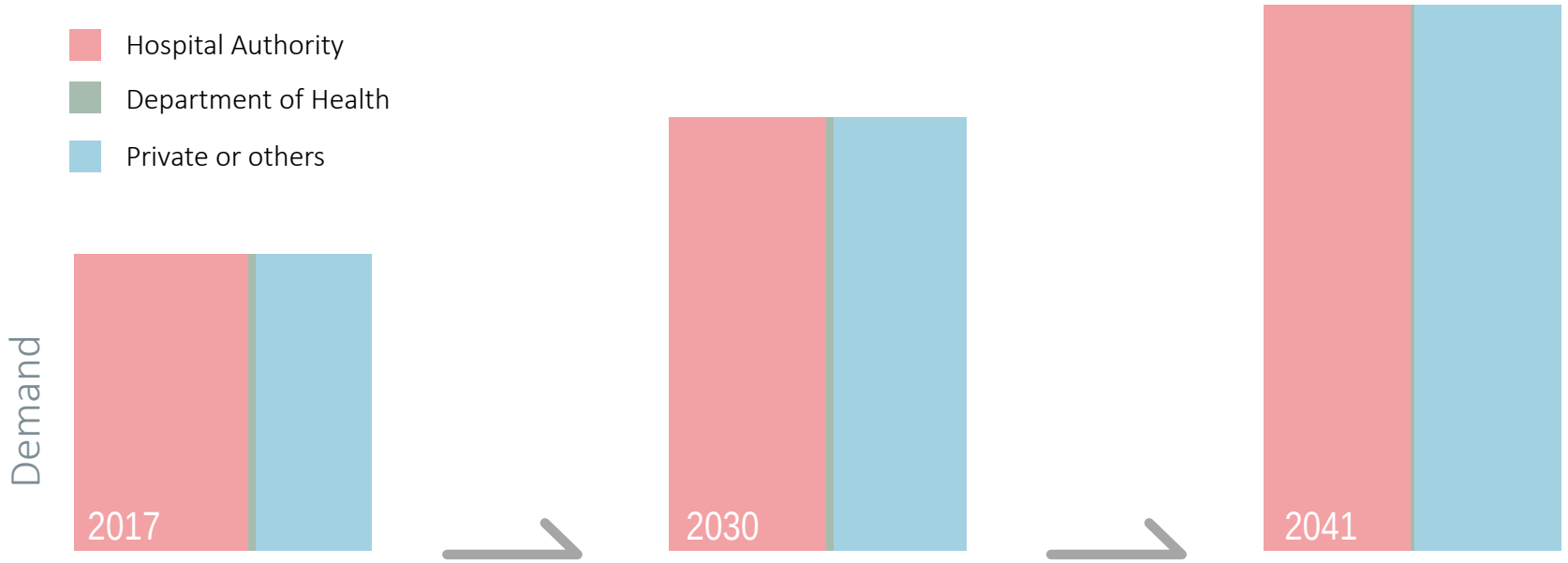




RADIOGRAPHER

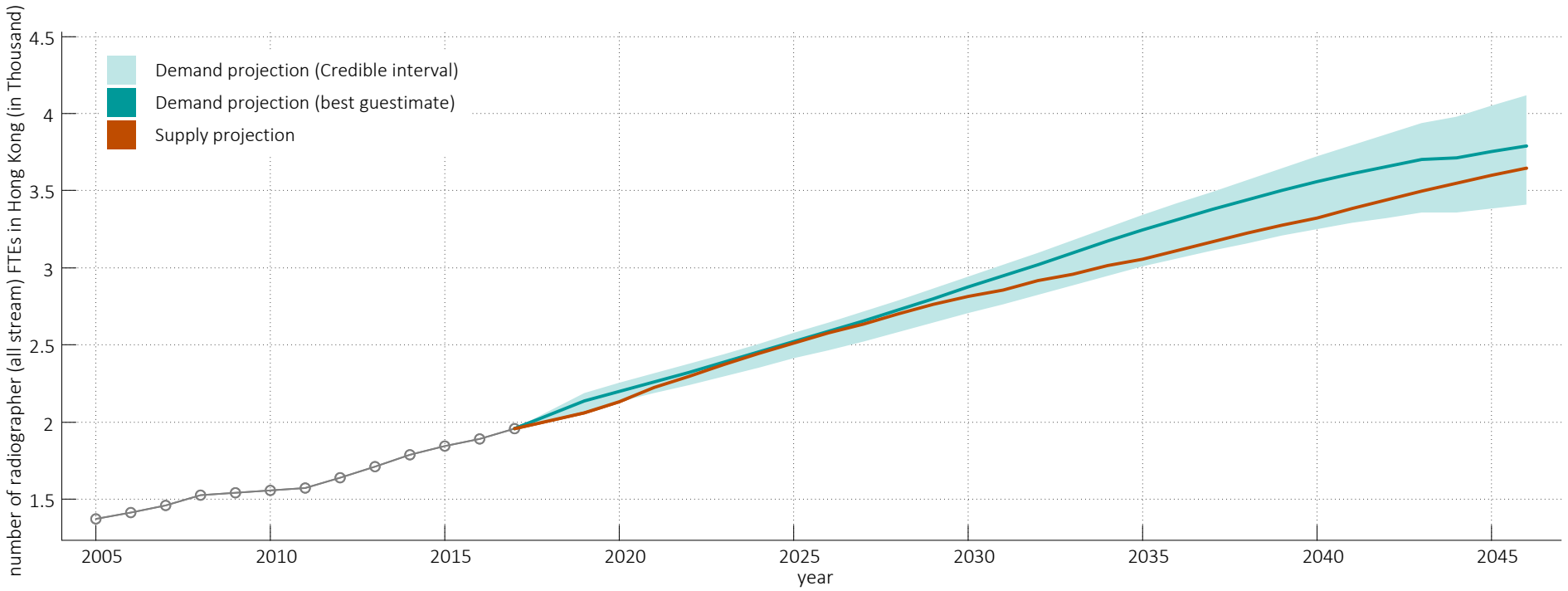


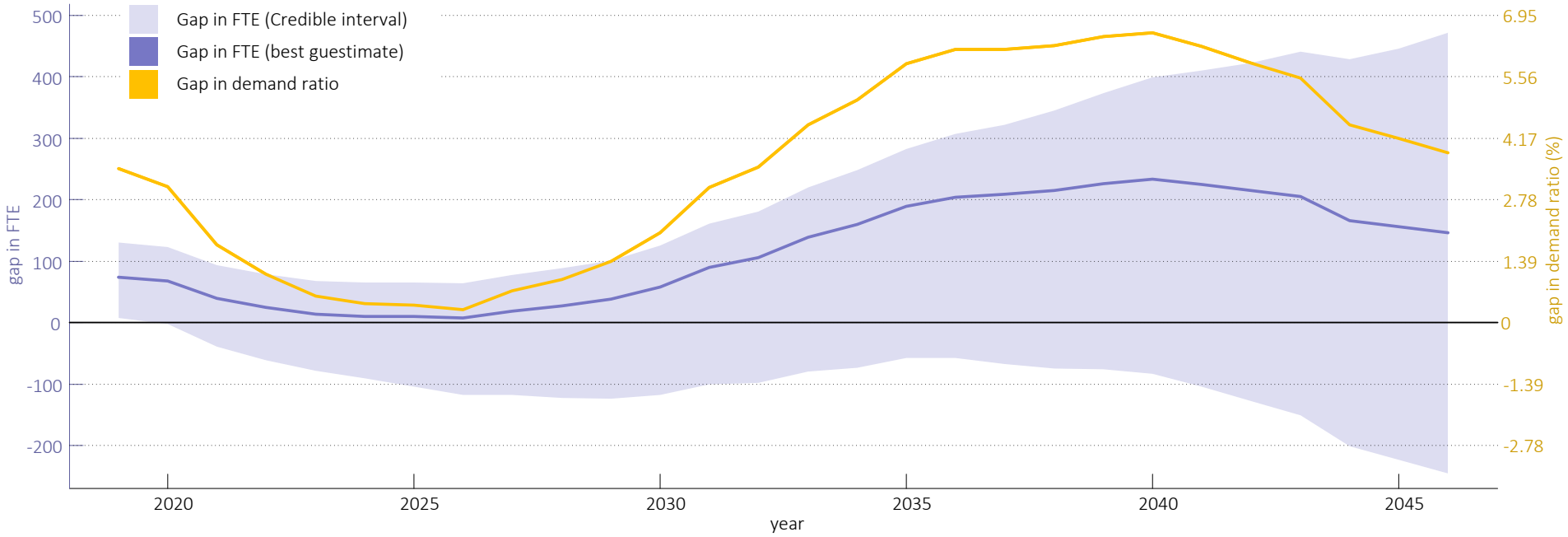
- No
  policy options/
  externalities



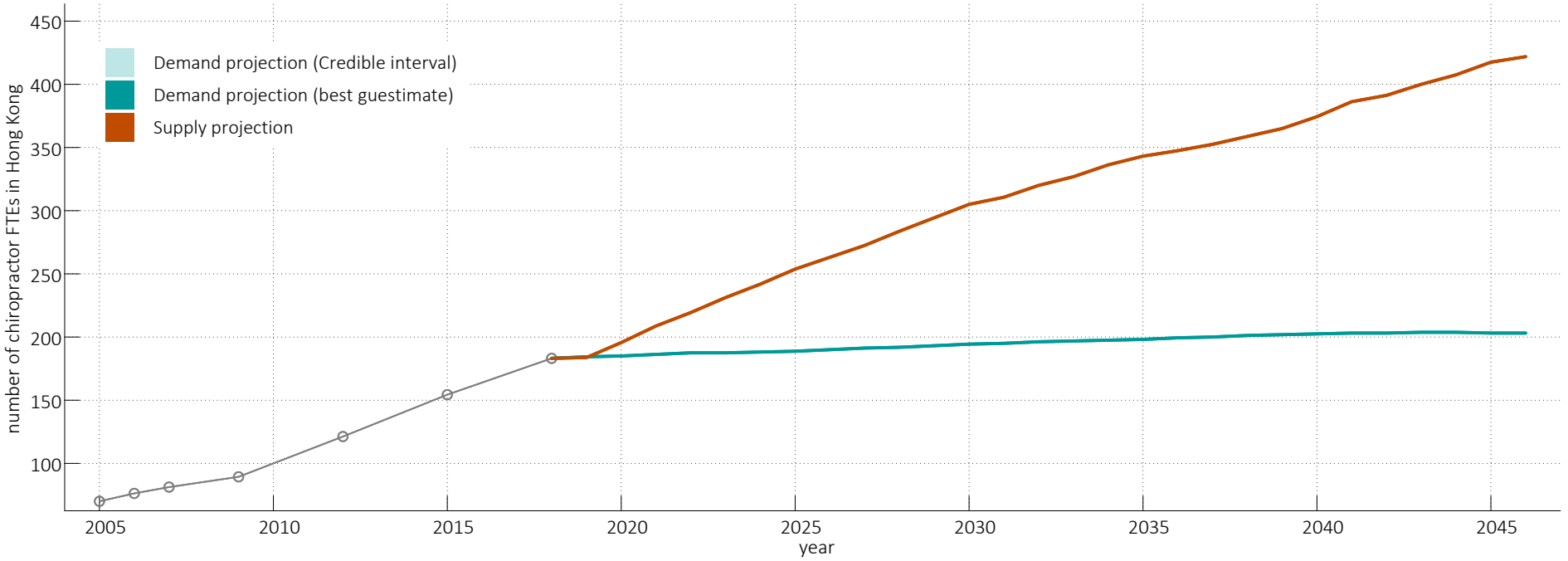
RADIOGRAPHER

GAP ANALYSIS

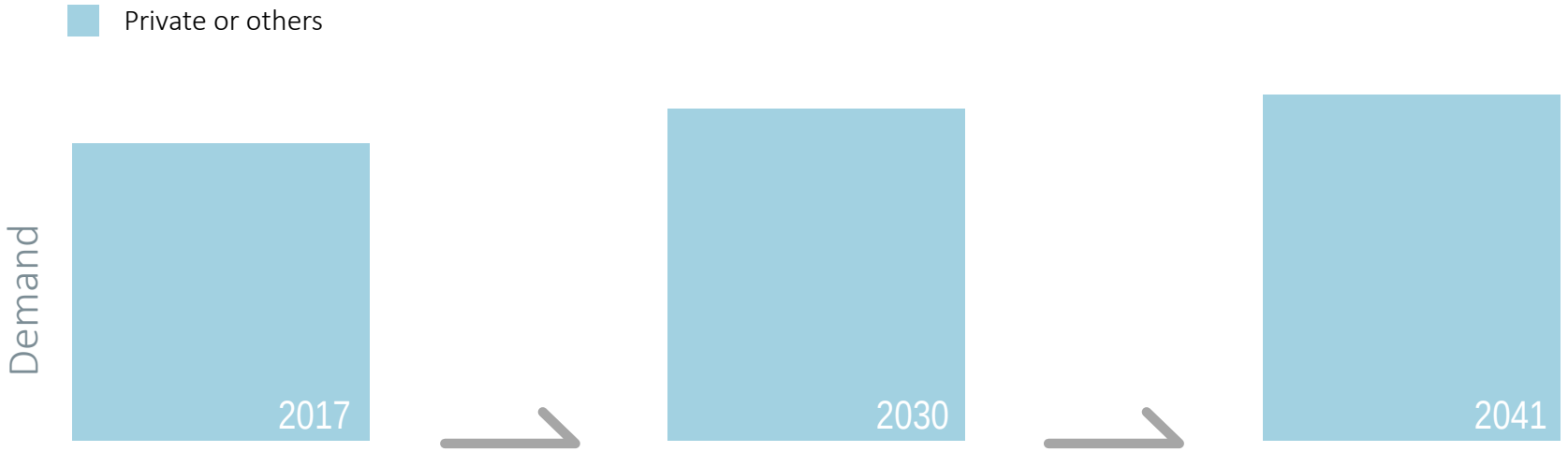




CHIROPRACTOR

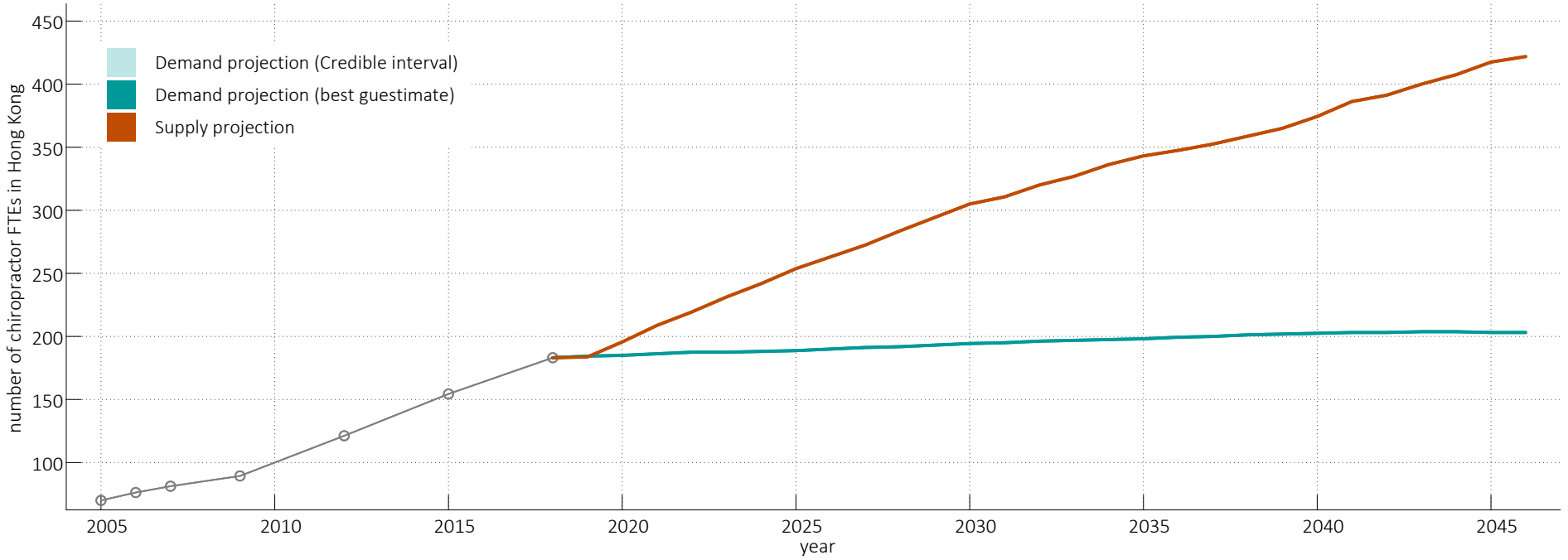


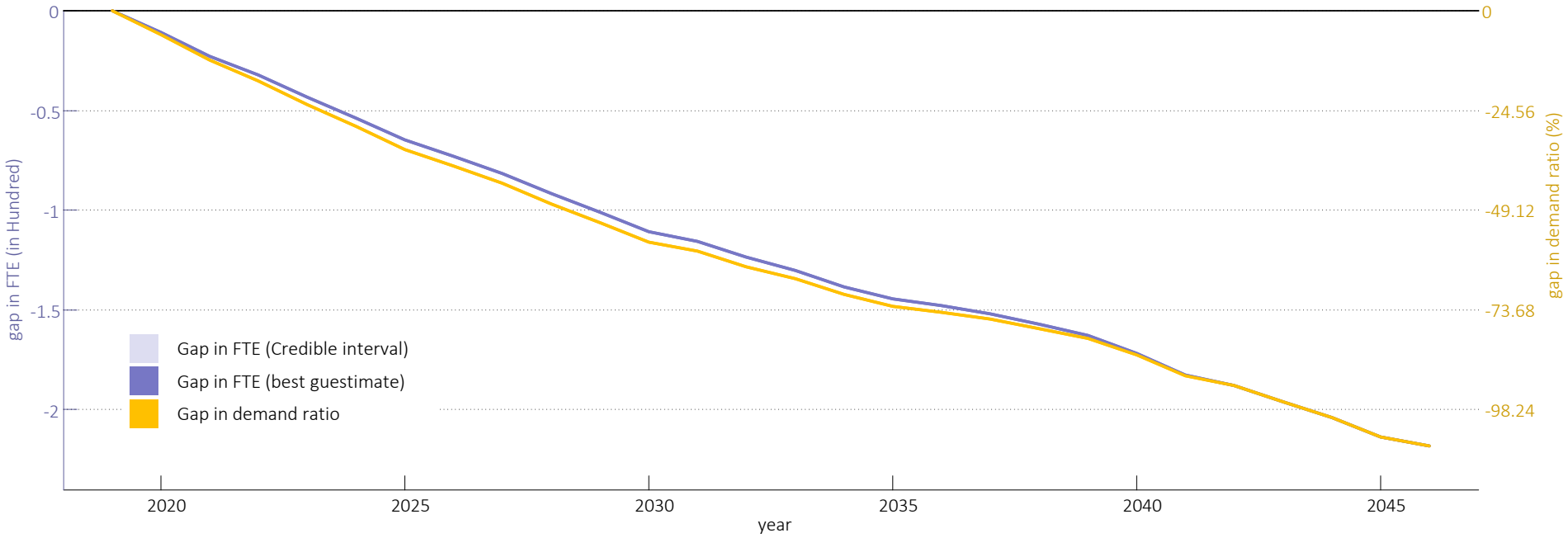
- No policy options/ externalities



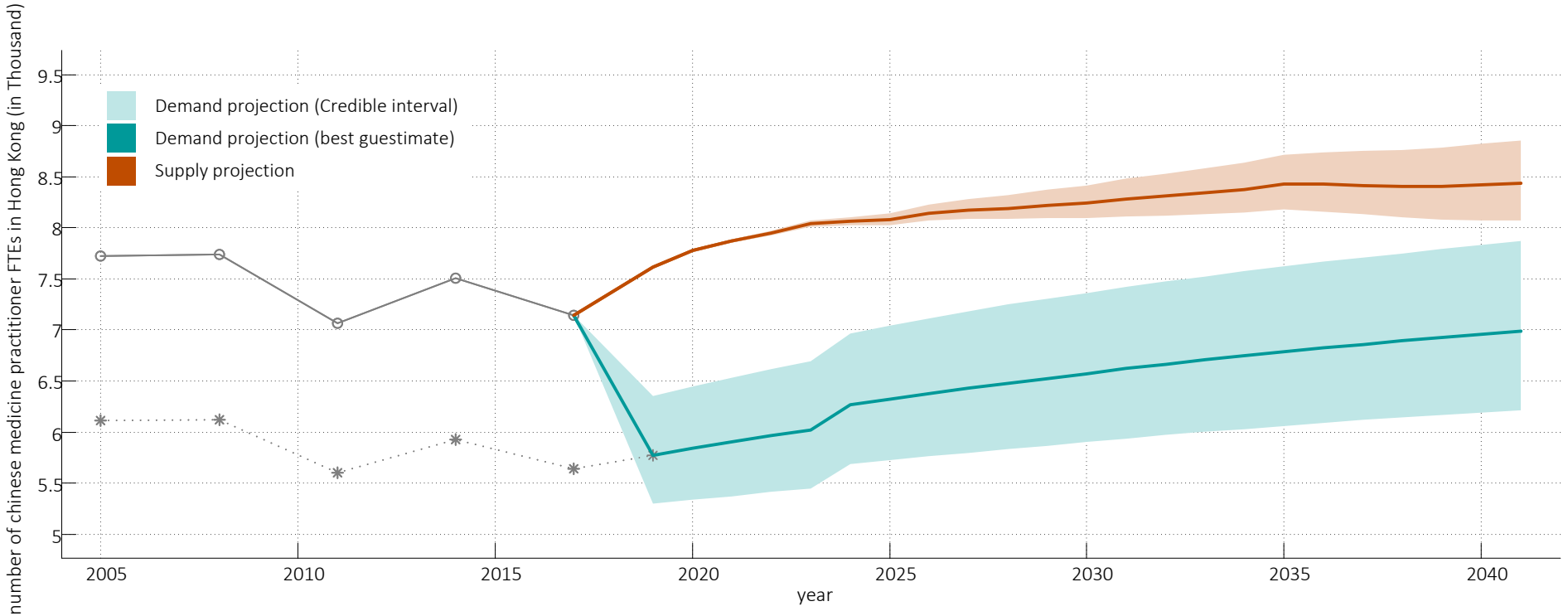
CHIROPRACTOR

GAP ANALYSIS



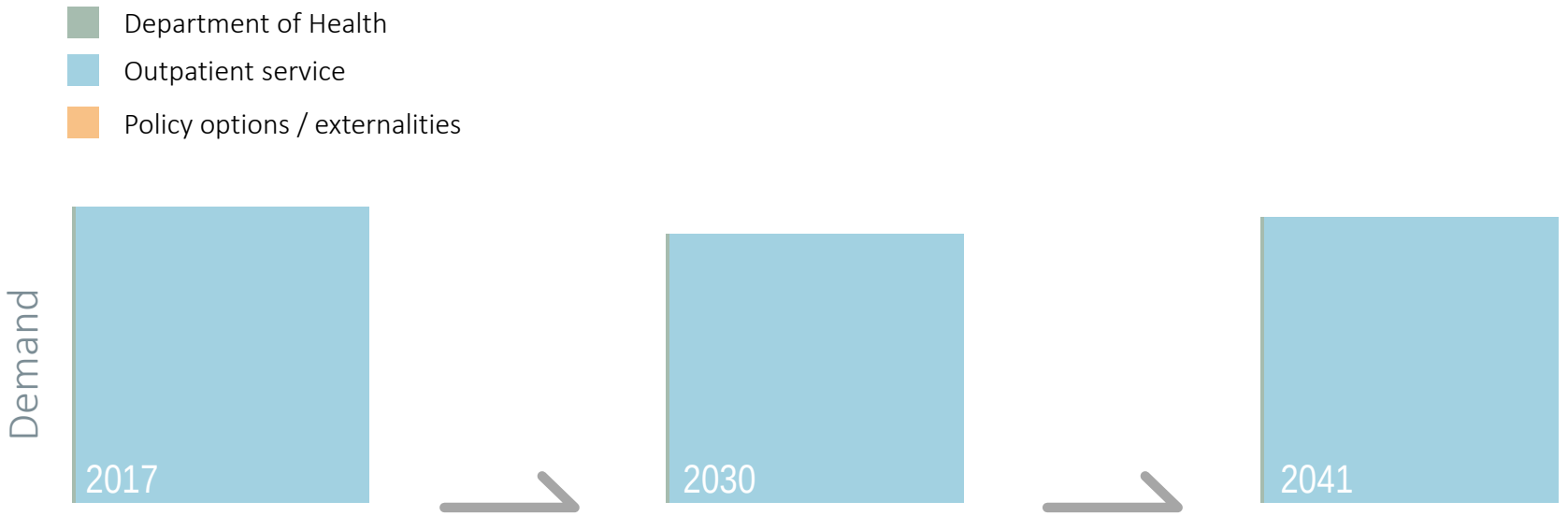


CHINESE MEDICINE PRACTITIONER



Policy options | Externalities

- Chinese Medicine Hospital
- Spare capacity in private sector



CHINESE MEDICINE PRACTITIONER

GAP ANALYSIS