Supply of and demand for radiologic technologist personnel in Taiwan: an analysis of 20 years

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Research

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Abstract

Background: Currently, nine universities and one junior college offer radiologic technologist (RT) programs (RTPs) in Taiwan. The curriculum, certificate examination, and licensing of RTs in RTPs in Taiwan are similar to those for RTPs in Japan and Korea. The present study explored the supply of and demand for RTs over the past 20 years and identified predictive indicators of trends affecting the numbers of RTs supplied and demanded.

Methods: The present study involved web-based research. The analyzed data were publicly available information downloaded from the websites of relevant statistical departments in Taiwan. The study employed specific medical devices or examinations used in hospitals to determine the demand for RTs. Long-term (1999–2018) and short-term (2014–2018) trends were analyzed. The change rates were calculated using compound annual growth rate (CAGR). Pearson's product–moment correlation coefficient or Spearman's rank correlation coefficient was used to evaluate two groups of continuous variables. Kolmogorov–Smirnov and Shapiro–Wilk tests were used to test normally distributed data.

Results: During 1999–2018, the annual numbers of students and graduates in RTPs were 2654 ± 350 and 516 ± 109, respectively, with corresponding CAGRs of 2.2% and 3.7%. During 2014–2018, the annual numbers of students and graduates in the RTPs were 2908 ± 67 and 605 ± 55, respectively, with corresponding CAGRs of −0.7% and 2.4%. During 1999–2018, the annual numbers of examinees and qualified personnel were 1228 ± 174 and 372 ± 62, respectively. The CAGRs for the number of qualified personnel were −1.5% and −4.7% during 1999–2018 and 2014–2018, respectively. The number of specific medical devices increased from 599 in 2000 to 1057 in 2018, whereas that of specific medical examinations increased from 1.7 million in 2000 to 5.3 million in 2018.

Conclusion: During 2014–2018, 605 students graduated from RTPs annually, with approximately 375 annually becoming qualified personnel in Taiwan. The increase in the numbers of specific medical devices and examinations resulted in an annual increase of 204 new positions for RTs.

Background

In Taiwan, academic training courses for radiologic technologists (RTs) began in 1965. Prior to 1990, only two junior colleges in Taiwan provided RT programs (RTPs). Currently, nine universities and one college offer RTPs in the form of nine bachelor's degree courses and one diploma course, respectively. The curriculum of RT training stipulates obtaining a minimum of 128 credits, including at least 58 credits from mandatory courses related to diagnosis, nuclear medicine, radiotherapy, and radiation safety. Students are expected to complete an additional 28 weeks of hospital internships [1]. After successful graduation from RTPs, students are eligible to take the certificate examination conducted by Taiwan's Ministry of Examination. A certificate is issued if a candidate's average score exceeds 60 points. When candidates become certified RTs, they can apply and register as RTs at hospitals in Taiwan. RTs have only one certificate examination and one work license. It is a single or all-in-one license and is not subdivided

into multiple licenses for diagnostic radiology, nuclear medicine, radiotherapy, ultrasound, and magnetic resonance (MR). This all-in-one pattern of the curriculum and certificate examination in RTPs and licensing of RTs is similar to patterns followed in Japan and Korea [3–5]. RTs work mainly in the radiology, nuclear medicine, and radiotherapy departments in Taiwan. Understanding national and global health labor market forces and trends is critical for developing effective health workforce plans [6–8]. Excess medical staff indicates workforce wastage and reduces wages. However, an inadequate workforce supply can undermine patients' rights and indirectly affects the health of the national population [9]. The present study explored the supply and demand for RTs over the past 20 years. We also identified predictive indicators of trends affecting the numbers of RTs supplied and demanded.

Methods

The present study involved web-based research. The analyzed data were publicly available information downloaded from the websites of relevant statistical departments in Taiwan. The numbers of students and graduates enrolled in each RTP with a bachelor's degree or diploma were obtained from Taiwan's Ministry of Education [10]. The numbers of examinees and qualified personnel who took the certificate examination were obtained from Taiwan's Ministry of Examination [11]. The certificate examination for RTs is conducted twice a year. The number of examinees and qualified personnel reported in the present study was the total of both examinations in a given year. In addition, the numbers of specific medical devices, patients undergoing specific medical examinations (diagnosis and radiation therapy), and registered RTs were obtained from Taiwan's Ministry of Health and Welfare [12]. Specific medical devices used or examinations conducted in hospitals indicated the following seven types of devices or examinations: computed tomography (CT) and magnetic resonance imaging (MRI) in the department of radiology; single photon emission computed tomography (SPECT) and position emission tomography (PET) in the department of nuclear medicine; and linear acceleration (LINAC), brachytherapy (Brachy), and proton therapy (Proton) in the department of radiation therapy [12]. Data on national population and gross domestic product (GDP) per capita were obtained from Taiwan's Ministry of Interior [13].

Statistical analysis

We analyzed long-term trends from 1999 to 2018 (or 2000 to 2018) and short-term trends from 2014 to 2018. The change rates in enrolled students, graduates, examinees, and qualified personnel were calculated using a compound annual growth rate (CAGR). The numbers of specific medical devices, patients with specific medical examinations, and registered RTs as well as GDP per capita exhibited a linear distribution; hence, linear regression analysis was performed. Pearson's product–moment correlation coefficient (r) was used to evaluate two groups of continuous variables, and the correlation indicated a normal distribution. For variables that did not exhibit a normal distribution, Spearman's rank correlation coefficient (r) analysis was used. The results of Kolmogorov–Smirnov and Shapiro–Wilk tests suggested that the numbers of graduates, qualified personnel, devices, patients, and RTs as well as GDP per capita exhibited a normal distribution. SPSS v17 and Excel 2016 were used to compile and analyze the data statistically.

Results And Analysis

The numbers of students who enrolled in and graduated from the RTPs in Taiwan form 1999 to 2018 are shown in Figure 1.

From 1999 to 2018, the annual number of students enrolled in RTPs at universities and the junior college was 2654 ± 350 (mean ± standard deviation), and the annual number of graduates was 516 ± 109. In the period of 2014–2018, the annual number of students was 2908 ± 67, and that of graduates was 605 ± 55. During 1999–2018, the number of students indicated a CAGR of 2.2%. However, during 2014–2018, the number of students did not increase, and the CAGR was −0.7%. The number of graduates revealed a CAGR of 3.7% during 1999–2018. Furthermore, during 2014—2018, the CAGR of the number of graduates was reduced to 2.4%. Because the number of students did not increase, the CAGR of the number of graduates is expected to decline beyond 2018.

Figure 2 shows the number of examinees taking RT examinations and qualified personnel during 1999–2018.

From 1999 to 2018, the annual number of examinees was 1228 ± 174 and the number of qualified personnel was 372 ± 62. During 1999–2018, the annual CAGR of the number of examinees taking Taiwan's RT examination was 1.0%; however, the CAGR reduced to 0.2% during 2014–2018. The CAGR of the number of qualified personnel was −1.5% and −4.7% during 1999–2018 and 2014–2018, respectively.

Taiwan's population increased from 22.3 million in 2000 to 23.6 million in 2018 [9]. The number of patients diagnosed or treated with a specific medical device each year was divided by the total population of the corresponding year and expressed as the frequency per 10000 people. Table 1 shows the frequency of seven specific medical examinations as well as long-term and short-term CAGRs. The SPECT and PET data of the nuclear medicine department from 2000 to 2004 are presented in total, without separate data. The corresponding long-term CAGR was calculated from 2005 to 2018. In the sum column of Table 1, the number of patients treated using Brachy during 2000–2004 is assumed to be 3 patients per 10,000 people.

Figure 3 shows the trends for the number of registered RTs, GDP (in US$) per capita, number of specific medical devices, and number and examinations. All the aforementioned numbers increased linearly from 1999 to 2018. The number of registered RTs increased from 2488 in 1999 to 6465 in 2018, which indicated an average increase of 204 RTs per year. The number of specific medical devices increased from 599 in 2000 to 1057 in 2018, which indicated an average annual increase of 25 devices. The number of specific medical examinations increased from 1.7 million in 2000 to 5.3 million in 2018, which indicated an average annual increase of 0.2 million patients.

The correlation between the number of RTs between 1999 and 2018 and each variable from among (1) number of enrolled students, (2) number of graduates, (3) number of examinees, (4) number of certificates, (5) number of specific medical devices, (6) number of specific medical patients, and (7) GDP

per capita was determined. With each variable, the coefficients of correlation of the number of RTs were specific devices (r = 0.997), specific patients (r = 0.995), GDP per capita (r = 0.978), graduates (r = 0.846), students (r = 0.828), examinees (r = 0.552), and qualified personnel (r = 0.080), in descending order.

Discussion

In 1999, only six universities and junior colleges in Taiwan provided RTPs. Within 5 years (in 2004), four additional universities provided RTPs. Consequently, from 1999 to 2008, the number of enrolled students increased at a CAGR of 4.6%. This also reflected an increase in the number of graduates during the same period; this increase exceeded the growth in the previous 5 years. New universities or junior colleges have not been added to the list of educational institutions providing RTPs since 2004. During 2014–2018, Taiwan's academic education for RTPs provided 605 ± 55 graduates each year. However, the number of certificates is 375 ± 32 per year, which is equivalent to 62% of graduates being eligible for employment in hospitals. Unqualified graduates are eligible to take examinations conducted every year.

In Taiwan, the GDP per capita increased from US$13,804 in 1999 to US$25,792 in 2018 [13]. GDP growth may have led to an increase in the number of specific medical devices and examinations. From 2000 to 2018, the total number of specific medical devices increased from 599 to 1057. The increase in the number of these medical devices is also reflected in the increase in the number of specific examinations.

As detailed Table 1, the examination frequency (patients per 10,000 people) in the long term, PET devices had fastest growth rate, followed by MRI devices. In the short term, the growth rate of proton devices was the fastest, whereas that of PET devices ranked second. In the long term, the number of patients exhibited a CAGR of 6% per year, whereas in the short term, the number declined slightly to 4% per year. In 2018, a total of 2227 specific medical diagnoses and treatments were performed per 10000 people. Among them, the major device distribution for patient examination was as follows: CT (49%), LINAC (25%), MRI (17%), SPECT (8%), PET (1%), proton (0.3%), and Brachy (0.1%). Operation of proton devices began in 2015, and such devices were purchased by another hospital in 2018. The number of patients receiving proton therapy increased from 534 in 2015 to 15,158 in 2018. Because some hospitals are still planning to purchase or have proton devices on order, the number of patients receiving proton therapy is expected to grow rapidly in the next 10 years [14].

Patients undergoing radiation or MRI examinations require the assistance of RTs. Hence, an increase in the demand for patient diagnosis or treatment may result in an increase in the number of RTs in hospitals, which will exceed the current requirement. Figure 3 shows that the number of RTs is not saturated, and 204 new positions are available each year in Taiwan. Over the past 5 years, the number of qualified personnel has been 375 per year. If 90% of qualified personnel eventually become RTs, approximately the retirement of 130 personnel will be required to fill in the remaining positions of qualified personnel. According to the calculated correlation coefficient, a steady increase in the number of devices and examinations is likely to be the main reason for the current increase in the number of RTs (204 new positions each year).

Limitations

Combining the numbers of seven specific medical devices may not be a appropriate approach because each device is different and the numbers of RTs required to operate them are different. Similarly, the usefulness of combining the numbers of seven specific medical examinations is also debatable. Strictly speaking, the average number of RTs required to operate each device or conduct each examination should be consider separately and added up after weighting is applied. In the absence of relevant references, we used unweighted sums for comparison. In addition, changes in the number of RTs are also closely related to political processes [15], such as a policy changes in Taiwan's National Health Insurance system. This study did not discuss the effects of policy change.

Conclusions

Taiwanese academic institutions provide 605 graduates from RTPs each year, and among those who graduate, approximately 375 become qualified personnel. Currently, the largest number of devices/treatments for specific medical diagnoses or treatments is CT followed by LINAC. The numbers of proton devices and patients receiving proton therapy are likely to increase at the fastest rate in the next decade. The growth of GDP per capita has led to a steady increase in the demand for specific medical devices and examinations, resulting in an annual increase of 204 new positions for RTs.

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Abbreviations

RT: radiologic technologist; RTPs: radiologic technologist programs; CAGR: compound annual growth rate; MR: magnetic resonance; CT: computed tomography; MRI: magnetic resonance imaging; SPECT: single photon emission computed tomography; PET: position emission tomography; LINAC: linear acceleration; GDP: gross domestic product

Declarations

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Not applicable

Authors’ contributions

YS and YH designed the study and contributed to the writing of the manuscript. HY participated in the data analyses and manuscript writing. YS and TR were responsible for the data analysis and drafted the manuscript. All authors have read and approved the final manuscript.

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Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information file.

Competing interests

The authors declare that they have no competing interests.

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Table

Table 1 Frequency (patients per 10,000 people) of seven medical examinations and long- and short-term CAGRs from 2000 to 2018.

Department	Radiology		Nuclear medicine		Radiation therapy			Sum
Year	CT	MR	SPECT	PET	LINAC	Brachy	Proton	
2000	310	78	99		278	NA	0	767
2001	316	87	108		313	NA	0	827
2002	358	108	114		392	NA	0	976
2003	376	122	120		426	NA	0	1047
2004	431	144	139		443	NA	0	1160
2005	431	139	128	6	504	3	0	1212
2006	450	149	139	8	473	3	0	1222
2007	497	167	173	11	507	4	0	1359
2008	551	185	217	12	515	3	0	1484
2009	602	209	183	13	475	3	0	1485
2010	633	226	191	13	524	3	0	1590
2011	675	235	197	13	494	3	0	1618
2012	728	255	202	14	503	3	0	1705
2013	768	272	196	15	527	3	0	1781
2014	811	288	212	16	543	2	0	1873
2015	880	314	165	21	536	3	0*	1920
2016	930	321	182	24	502	3	3	1965
2017	1008	359	193	23	520	3	4	2109
2018	1083	383	181	25	546	3	6	2227
CAGR (19 y)	7%	9%	2%	10%	4%	-1%	NA	6%
CAGR (5 y)	6%	6%	-3%	9%	0%	2%	131%†	4%

* 0.23 patients per 10,000 people.

† Result during 2015–2018 (4 years).

Figures

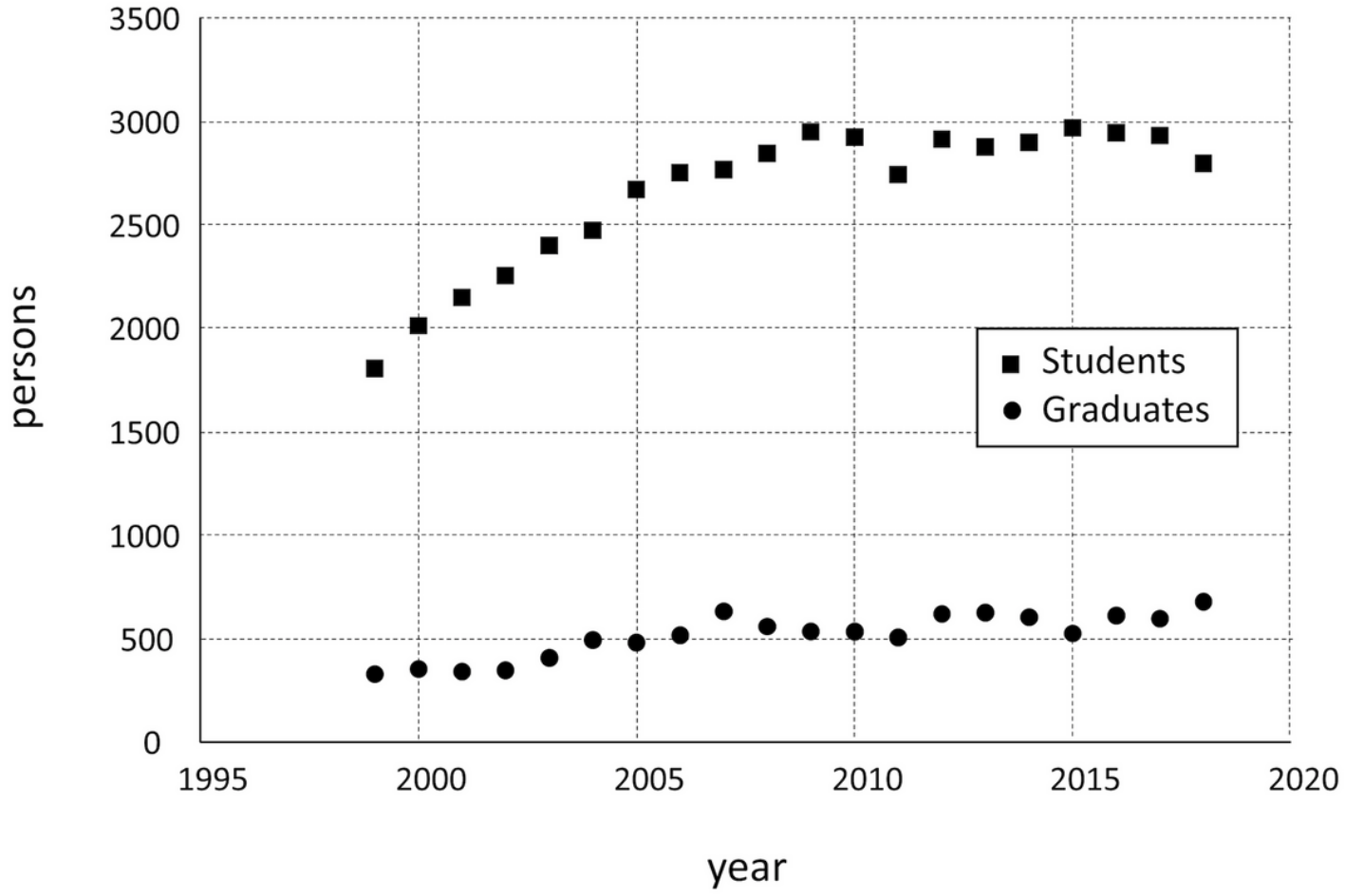

Figure 1

Numbers of students who enrolled in and graduated from RTPs in Taiwan during 1999–2018.

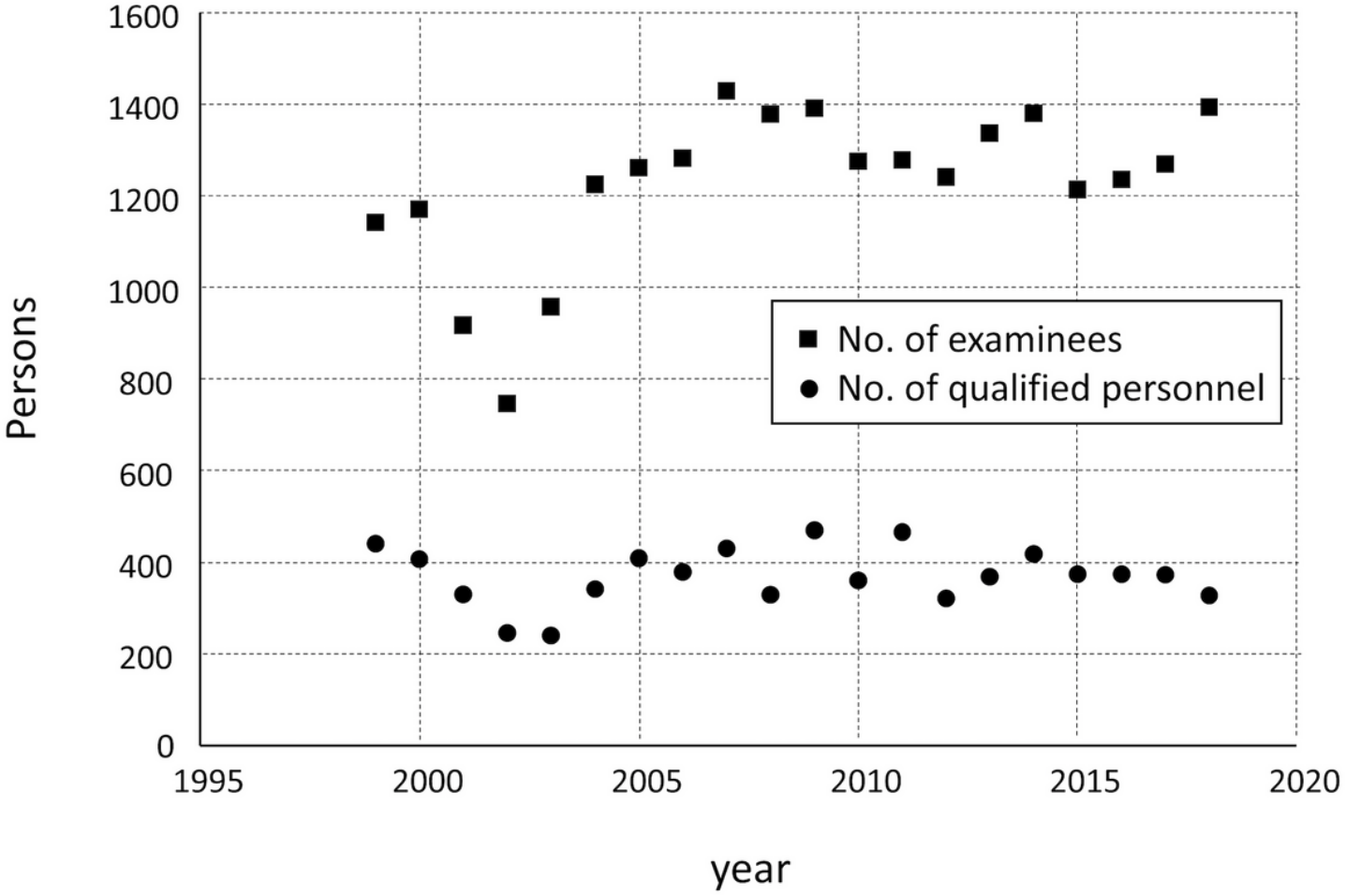

Figure 2

Numbers of examinees taking RT examinations and qualified personnel during 1999–2018.

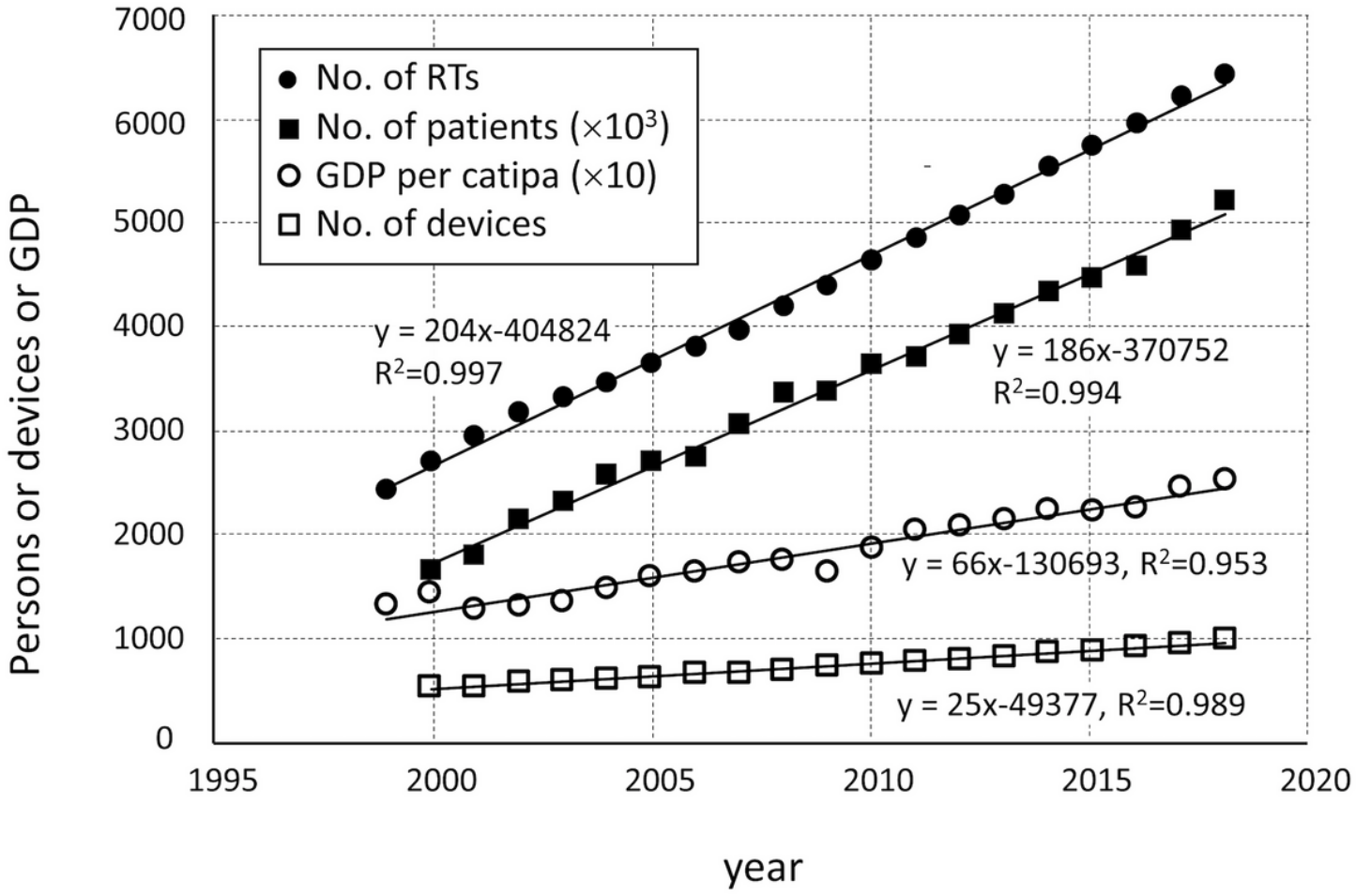

Figure 3

Number of registered RTs, GDP per capita, number of specific medical devices and patients, and their respective linear regressions during 1999–2018.