Experience of caring for patients with COVID-19 and educational achievement among Japanese resident physicians: a nationwide survey with general medicine in-training examination

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Abstract

Background As healthcare professional trainees, resident physicians are expected to help with COVID-19 care in various ways. Many resident physicians worldwide have cared for COVID-19 patients despite the increased risk of burnout. However, few studies have examined the experience with COVID-19 care among resident physicians and its effects on competency achievement regarding clinical basics and COVID-19 patient care.

Method This nationwide, cross-sectional Japanese study used a clinical training environment questionnaire for resident physicians (PGY-1 and − 2) in 593 teaching hospitals during the General Medicine In-Training Examination in January 2021. The General Medicine In-Training Examination questions comprised four categories (medical interviews and professionalism; symptomatology and clinical reasoning; physical examination and clinical procedures; and disease knowledge) and a COVID-19-related question. We examined the COVID-19 care experience and its relationship with the General Medicine In-Training Examination score, adjusting for resident and hospital variables.

Results Of the 6,049 resident physicians, 2,841 (47.0%) had no experience caring for patients with COVID-19 during 2020. Total and categorical General Medicine In-Training Examination scores were not different irrespective of the experience with COVID-19 patient care. For the COVID-19-related question, residents with experience in COVID-19 care showed a significant increase in correct response by 2.6% (95% confidence interval, 0.3–4.9%; $p = 0.028$).

Conclusions The resident physicians' COVID-19 care experience was associated with better achievement of COVID-19-related competency without reducing clinical basics. However, approximately half of the residents missed the critical experience of caring for patients during this unparalleled pandemic in Japan.

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Background

The coronavirus disease-2019 (COVID-19) has spread worldwide since the end of 2019 [1]. As a result, hospitals received many COVID-19 patients, which affected physicians' residency training [2]. Many resident physicians globally cared for COVID-19 patients. With the growing demand for COVID-19 care, the opportunity for COVID-19 care increased. However, resident physicians who were exposed to COVID-19 patients experienced a higher rate of stress and burnout compared to those who were not [3]. On the other hand, engaging in COVID-19 care could help physicians learn medical professionalism, system-based care, communication skills, and clinical knowledge of COVID-19 care [4]. Nonetheless, physician trainees must also obtain competency in clinical basics during their training [5].

In Japan, training hospitals may have limited residents' practice, including in COVID-19 care, to prevent the spread of COVID-19 in their hospital at the early stages of the pandemic. However, the impact of this situation on the achievement of clinical competency among resident physicians has not been elucidated. A two-year residency training program for postgraduate physicians has been mandatory in Japan since 2004 to achieve basic clinical competency. Resident physicians must rotate through different clinical departments, including emergency medicine, pediatrics, obstetrics and gynecology, psychiatry, internal medicine, surgery, and community medicine [6]. The COVID-19 pandemic may have also limited the provision of patient care, including COVID-19 care, by resident physicians who rely on patient care experience to achieve basic clinical competency during the rotation of the residency program.

Furthermore, the global pandemic may have affected resident physicians' training process; however, no nationwide study has examined the relationship between experience in COVID-19 care and achievement of basic clinical competency during residency training. A nationwide survey in 2020 in Saudi Arabia showed that 43% of resident physicians experienced direct COVID-19 care, with 44% proper use of personal protective equipment (PPE) [7]. In another study, orthopedics and traumatology resident physicians in Germany responded that 80% were set back in time of their general training due to the pandemic [8]. Meanwhile, in Turkey, 90% of family medicine residency trainees were negatively affected by COVID-19, with a total of 31% having depression and 24% facing severe burnout problems [9]. Chinese radiology and U.S. Veterans Affairs residents expressed decreased satisfaction with training [10, 11]. However,

few studies have investigated resident physicians' experience in COVID-19 care and its effects on competency achievement in clinical basics and COVID-19 care. Thus, this study examines the relationship between the experience of caring for patients with COVID-19 and competency in clinical basics and COVID-19 care based on a nationwide General Medicine in-Training Examination (GM-ITE) with a resident survey in Japan.

Methods

Study design

This nationwide, multicenter, cross-sectional study was conducted in Japan. We used a self-reported questionnaire to clarify the educational environment of resident physicians, including their experience of caring for patients with COVID-19. The co-authors iteratively modified this questionnaire independently of the prior literature because the COVID-19 pandemic was unprecedented. We examined the experience of caring for COVID-19 patients and its relationship with the General Medicine In-Training Examination score in 2020, as described below. This study was approved by the Institutional Review Board of the Japan Institute for Advancement of Medical Educational Program (JAMEP) (No. 22–25). This cross-sectional study adhered to the STROBE guidelines.

Participants

The present study included postgraduate year 1 (PGY-1) and PGY-2 resident physicians who attempted the General Medicine In-Training Examination in Japan at the end of the 2020 fiscal year (from January 13 to 31, 2021). Only resident physicians who consented to participate in this study were included. Resident physicians with missing data in the self-reported questionnaire, including data on their experience in caring for patients with COVID-19, were excluded.

General medicine in-training examination

The JAMEP, a non-profit organization, has been conducting annual examinations of resident physicians (PGY-1 and PGY-2) to evaluate their basic clinical competency since 2011 [12–17]. The General Medicine In-Training Examination is administered in Japan. It is similar to the US Residency Internal Medicine in-Training Examination that assesses resident physicians' clinical knowledge. The General Medicine In-Training Examination aims to provide residents and training program directors with an objective, a reliable, and a validated assessment of clinical knowledge. The examination includes important

disciplines focusing on primary care to evaluate resident physicians' competency regarding clinical basics. In January 2021, the General Medicine In-Training Examination included 60 questions on four main topics: medical interviews and professionalism (six questions), symptomatology and clinical reasoning (15 questions), physical examination and clinical procedures (15 questions), and disease knowledge (24 questions). Some of the questions were in video and audio formats. The questions are developed annually by an independent committee of board-certified physicians. The General Medicine In-Training Examination can only be attempted by residents who work in training hospitals authorized to administer the examination.

Data collection and variables

We collected data on resident physicians' educational environments and hospital characteristics. These characteristics were divided into resident and hospital variables. A self-reporting questionnaire included the following resident variables: PGY grade, sex, desired specialty, rotational training in the Department of GM, rotational training in the Department of Internal Medicine, night duty work in the emergency room (ER) during a residency program, mean number of caring for inpatients, mean self-study time per day, frequency of case conferences per week, and supply of PPE for caring for a patient with COVID-19, from a self-reporting questionnaire sheet. The residents were divided into the following five groups based on the number of COVID-19 patients they treated: 0 patients, 1–10 patients, 11–20 patients, 21–30 patients, and 31 patients or more. The present study defined experiencing care of one or more patients as the presence of experience with COVID-19 ("0 patient" as no experience).

The following training hospital variables were extracted from the hospitals' websites: the location of each hospital, region (47 prefectures in Japan), region-level state of the COVID-19 pandemic, category of an infectious disease-designated medical institution, hospital function, university hospital or community hospital, and administration type. The high-incidence areas of COVID-19 were determined from published websites, and there were 23 high-incidence areas among the 47 prefectures.

The outcome variables were determined from the total and four categorical General Medicine In-Training Examination scores: (1) general skills (medical interview and professionalism), (2) symptomatology and clinical reasoning, (3) physical examination and clinical procedures, and (4) disease knowledge. In addition, the examination included one COVID-19-specific question, which was developed by two certified physicians for selection validity and reliability (Additional file 1 Supplementary Questionnaire).

Statistical analysis

The primary outcome measure was the General Medicine In-Training Examination score. We examined the difference in General Medicine In-Training Examination scores based on the presence and absence of experience in caring for patients with COVID-19, which was estimated using linear generalized estimating equation (GEE) models by clustering hospitals. The GEE does not require many observations (i.e., physicians) in each cluster (i.e., hospitals) to obtain valid point and interval estimates as the number of clusters increases. The model adjusted for resident variables (graduated years, sex, desired specialty, general medicine rotation, internal medicine rotation, night shift in ER department, number of care patients, study time, frequency of case conference, and PPE supply) and hospital variables (hospital location, hospital function, pandemic area for COVID-19, designated hospitals for specified infectious diseases, urban or rural, university or community hospital, and administration type). A similar model was applied to the COVID-19-specific question (binary outcome); the estimate represented the difference in the correct response rate between the groups. Each background variable was analyzed for association of presence of experience with COVID-19 in univariable and multivariable models using clustered log-linear 'modified' Poisson models. Statistical significance was set at a two-tailed p-value < 0.05. All statistical analyses were performed using the geeglm function in the "geepack" package of the R software.

Results

Among the 7,669 residents who attempted the General Medicine In-Training Examination in January 2021 from 593 teaching hospitals, 6,049 residents were finally included in this study (Fig. 1). The response rate was 78.9%. It was found that 2,841 residents cared for 0 COVID-19 patients (47.0%; 95% confidence interval [CI], 45.7–48.2%), 2,733 cared for 1–10 patients (45.2%), 305 cared for 11–20 patients (5.0%), 73 cared for 21–30 patients (1.2%), 97 cared for more than 31 patients (1.6%). There was no significant tendency between the total score of the General Medicine In-Training Examination (including scores of the four test categories) and the number of experiences caring for patients with COVID-19 (data not shown).

Table 1 reveals background characteristics divided into resident and hospital variables. The number of male residents exceeded that of female residents. Most of the resident physicians (total 84%) sufficiently supplied PPE in the fiscal year 2020. Training hospitals for residents were more in rural than urban areas.

Table 2 shows resident variables associated with the experience of caring for patients with COVID-19. Significant residents' variables associated with the experience
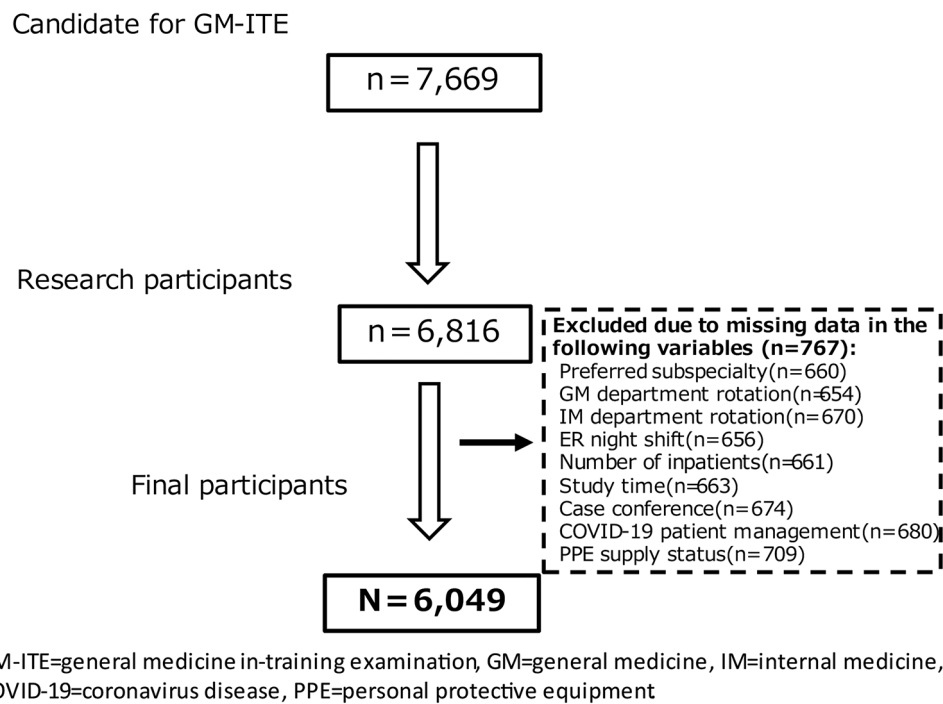
Candidate for GM-ITE

n = 7,669

Research participants

n = 6,816

Excluded due to missing data in the following variables (n=767):
Preferred subspecialty(n=660)
GM department rotation(n=654)
IM department rotation(n=670)
ER night shift(n=656)
Number of inpatients(n=661)
Study time(n=663)
Case conference(n=674)
COVID-19 patient management(n=680)
PPE supply status(n=709)

Final participants

N = 6,049

GM-ITE=general medicine in-training examination, GM=general medicine, IM=internal medicine, COVID-19=coronavirus disease, PPE=personal protective equipment

Fig. 1 Inclusion criteria flow chart

were PGY-2, man, resident physicians who were interested in specialty as ER physicians, resident physicians who worked greater hours in the ER, resident physicians who cared for patients with COVID-19, resident physicians who had a significant amount of study time, and resident physicians who received a sufficient supply of PPE.

Table 2 also includes hospital variables associated with the experience of caring for patients with COVID-19. Significant hospital variables associated with the experience were urban areas, Kanto (close to Tokyo) or Kinki (close to Osaka), high-incidence areas for COVID-19, and non-designated hospitals for specified infectious diseases.

Sixty questions were provided in the General Medicine In-Training Examination in January 2021. As shown in Table 3, univariable GEE analysis of the relationship between difference in General Medicine In-Training Examination scores based on the experience in caring for patients with COVID-19 revealed the following: total score (score difference 0.436, 95% CI, 0.052–0.820; $p=0.026$), symptomatology and clinical reasoning (score difference 0.120, 95%CI, 0.001–0.238; $p=0.047$), and COVID-19-related question (score difference 0.046, 95%CI, 0.023–0.069; $p<0.001$). After adjustment for resident and hospital variables, the COVID-19-related question (score difference 0.026, 95%CI, 0.003–0.049; $p=0.028$) was significantly associated with experience in caring for patients with COVID-19 (Table 3).

Discussion

The present study is the first to use nationwide data from Japan to investigate the effect of caring for patients with COVID-19 on the educational achievements of resident physicians during the COVID-19 pandemic. Fewer than half of the Japanese resident physicians (47%) had no experience caring for COVID-19 patients in 2020. It was found that experience in caring for patients with COVID-19 did not significantly affect the total score obtained in the General Medicine In-Training Examination, but it did affect the score for the COVID-19-related question; resident physicians who had experience in treating patients with COVID-19 scored higher than those who did not.

An unexpected finding was that approximately half of the Japanese resident physicians (47%) did not care for COVID-19 patients during the initial phase of the COVID-19 pandemic. The result revealed that percentage of Japanese resident physicians with experience in COVID-19 is too low, even though it is early in the COVID-19 pandemic. However, almost all cared for in-patients and worked in the ER 3–5 times a month (Table 1). Furthermore, in the initial phase of the COVID-19 epidemic, the ER training frequency of the Japanese resident physicians was almost the same as that before the outbreak. Thus, training hospitals in rural and non-contaminated areas could have failed to provide resident physicians with the opportunity to care for patients with COVID-19 (Table 2).

As mentioned earlier, the present study revealed that COVID-19 care did not affect resident physicians'

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Table 1 Background variable (*N*=6,049)

Resident variable		n	(%)
Grade	PGY-1	3,072	(51)
	PGY-2	2,977	(49)
Sex	Male	4,107	(68)
	Female	1,942	(32)
Hoped specialty department	Internal medicine	2,163	(36)
	Surgery	1,258	(21)
	General medicine	146	(2)
	Emergency room	209	(3)
	Others	2,273	(38)
General medicine rotation	No	3,461	(57)
	Yes	2,588	(43)
Internal medicine rotation	0–5 month	1,182	(20)
	6–10 month	3,813	(63)
	11–15 month	1,054	(17)
Emergency department duty per month	0 per month	218	(4)
	1–2 per month	927	(15)
	3–5 per month	4,255	(70)
	≥6 per month	617	(10)
	Unknown	32	(1)
Care of in-patients	0–4 patients	1,420	(23)
	5–9 patients	3,633	(60)
	10–14 patients	675	(11)
	≥ 15 patients	172	(3)
	Unknown	149	(2)
Study time	0–30 minutes per day	2,059	(34)
	31–60 minutes per day	2,515	(42)
	61–90 minutes per day	1,007	(17)
	≥91 minutes per day	255	(4)
	Unknown	213	(4)
Case conferences in a hospital	0 per week	990	(16)
	1 per week	2,987	(49)
	2 per week	1,268	(21)
	3 per week	348	(6)
	4 per week	456	(8)
PPE supply status	Completely sufficient supply	2,844	(47)
	Sufficient supply	2,228	(37)
	Neither	622	(10)
	Insufficient supply	295	(5)
	Completely insufficient supply	60	(1)
Hospital variable			
Location	Rural area	4,048	(67)
	Urban area	2,001	(33)
Region	Hokkaido	206	(3)
	Tohoku	454	(8)
	Kanto	1,751	(29)
	Chubu	907	(15)
	Kinki	1,353	(22)
	Chugoku	389	(6)
	Shikoku	232	(4)
	Kyushyu/Okinawa	757	(13)
Epidemic area for COVID-19	Non-contaminated area	2,605	(43)
	Contaminated area	3,444	(57)
Category of infectious disease designated medical institution	Specific-designated medical institutions for specified infectious diseases	4	(0)

Table 1 (continued)

Resident variable		n	(%)
	Class 1-designated medical institutions for specified infectious diseases	570	(9)
	Class 2-designated medical institutions for specified infectious diseases	1,946	(32)
	Non-designated medical institutions for specified infectious diseases	3,529	(58)
Hospital function	Small and middle-sized hospital	1,325	(22)
	Advanced treatment hospital	712	(12)
	Regional medical care support hospital	4,012	(66)
University or community hospital	University	682	(11)
	University-branch hospital	312	(5)
	Community hospital	5,055	(84)
Administration type	National hospital organization's hospital	260	(4)
	Japan community health care organization's hospital	60	(1)
	Industrial accident compensation hospital	140	(2)
	Prefectural hospital	411	(7)
	Ordinance designated city hospital	161	(3)
	Municipality-owned hospital	725	(12)
	Others	4,286	(71)

COVID-19 = coronavirus disease, PGY = post graduate year, PPE = personal protective equipment

General Medicine In-Training Examination scores. This suggests that resident physicians who cared for patients with COVID-19 did not experience a reduction in educational achievement. Perhaps because the ratio of resident physicians who cared for over 21 patients with COVID-19 was low (2.8%) in the early stage of the COVID-19 pandemic, indicating a low medical load, COVID-19 care did not reduce education achievement. Moreover, caring for patients with COVID-19 may improve clinical knowledge associated with COVID-19 care; the COVID-19-related question was correctly answered by over 80% of the resident physicians, as shown in Table 3. This question has a 4.6% significance level for the correct answer rate between the presence and absence of experience in caring for patients with COVID-19, which may be valuable for clinical practice. Therefore, experience of caring for patients with COVID-19 may contribute to the acquisition of clinical knowledge, and COVID-19 care may not negatively impact Japanese resident physicians' educational outcomes.

In the sub-analysis of the number of experiences caring for COVID-19 patients (data not shown), the univariable analysis showed no difference in General Medicine In-Training Examination scores between the 0 patients, 1–20 patients, or >21 patients groups. The analysis found a tendency for a sufficient supply of PPE and an increased number of care for patients with COVID-19. This result indicates that training hospitals with sufficient PPE supply were affirmatively involved in resident physicians' training for COVID-19 care early in the COVID-19 pandemic. In a further sub-analysis between the PGY-1 and PGY-2, the same tendency was observed in the correct answer rate to the COVID-19-related question and experience in caring for patients with COVID-19

(Additional file 2 Supplementary Table). However, among only the PGY-2 resident physicians, experience in caring for patients with COVID-19 was significantly associated with the correct answer of the COVID-19-related question (Additional file 2 Supplementary Table). Thus, it may be speculated that those in PGY-2 had not only more experience in but also greater responsibility toward patient care, including of patients with COVID-19, than those in PGY-1 [18].

To the best of our knowledge, this is the first multi-level study to determine the relationship between experience in caring for COVID-19 patients and the medical achievement of resident physicians. Extant studies have examined the medical education of under-graduate medical students during the COVID-19 pandemic [19–21]. However, only a few studies have qualitatively examined the post-graduate medical education of resident physicians [4, 22–25]. Previous research has focused on specific department resident physicians (e.g., emergency medicine in the U.S., surgery in the Netherlands, and surgery and anesthesiology in the U.S.) and used a small sample of resident physicians. The present study examined the characteristics of resident physicians in various departments. Therefore, the results of this study may be useful for resident physicians in other countries with a similar rotational system.

Furthermore, the sample size was large, accounting for one-third of the resident physicians in Japan. In short, among about 18,000 resident physicians reported by the Japanese government [26], the present study involved 6,049 resident physicians. Therefore, this study has high internal validity because of the large sample size. In addition, the General Medicine In-Training Examination has been administered over a long period since 2011, with

Table 2 Factors associated with the experience regarding the care of patients with COVID-19 (N=6,049)

Resident variable		n	COVID-19 care		Univariable		Multivariable adjusted	
			no (%), n=2841	yes (%), n=3208	probability ratio	95%CI	probability ratio	95%CI
Grade	PGY-1	3,072	1,496 (-48.7)	1,576 -51.3	1	Reference	1	Reference
	PGY-2	2,977	1,345 -45.2	1,632 -54.8	1.07	1 – 1.14*	1.07	1.01 – 1.14*
Sex	Male	4,107	1,815 -44.2	2,292 -55.8	1	Reference	1	Reference
	Female	1,942	1,026 -52.8	916 -47.2	0.85	0.8 – 0.9*	0.86	0.82 – 0.91*
Hoped specialty department	Internal medicine	2,163	999 -46.2	1,164 -53.8	1	Reference	1	Reference
	Surgery	1,258	575 -45.7	683 -54.3	1.01	0.94 – 1.08	0.99	0.93 – 1.05
	General medicine	146	71 -48.6	75 -51.4	0.96	0.78 – 1.17	1.06	0.9 – 1.25
	Emergency room	209	64 -30.6	145 -69.4	1.29	1.17 – 1.42*	1.23	1.11 – 1.37*
	Others	2,273	1,132 -49.8	1,141 -50.2	0.93	0.88 – 0.99*	0.96	0.91 – 1.01
General medicine rotation	No	3,461	1,634 -47.2	1,827 -52.8	0.99	0.9 – 1.004	1.02	0.94 – 1.08
	Yes	2,588	1,207 -46.6	1,381 -53.4	1	Reference	1	Reference
Internal medicine rotation	0–5 month	1,182	553 -46.8	629 -53.2	1	Reference	1	Reference
	6–10 month	3,813	1,812 -47.5	2,001 -52.5	0.99	0.92 – 1.06	0.99	0.92 – 1.05
	11–15 month	1,054	476 -45.2	578 -54.8	1.04	0.94 – 1.15	0.99	0.91 – 1.09
Emergency department duty per month	0 per month	218	147 -67.4	71 -32.6	1	Reference	1	Reference
	1–2 per month	927	510 -55	417 -45	1.38	1.04 – 1.83*	1.32	1.02 – 1.71*
	3–5 per month	4,255	2,017 -47.4	2,238 -52.6	1.62	1.2 – 2.18*	1.45	1.13 – 1.86*
	≥6 per month	617	149 -24.1	468 -75.9	2.33	1.71 – 3.17*	1.97	1.54 – 2.51*
	Unknown	32	18 -56.3	14 -43.8	1.34	0.89 – 2.07	1.49	0.98 – 2.27
Care of in-patients	0–4 patients	1,420	762 -53.7	658 -46.3	1	Reference	1	Reference

Table 2 (continued)

Resident variable		n	COVID-19 care				Univariable			Multivariable adjusted		
			no (%), n=2841		yes (%), n=3208		prob-ability ratio	95%CI		prob-ability ratio	95%CI	
	5–9 patients	3,633	1,718	-47.3	1,915	-52.7	1.14	1.04	1.24*	1.04	0.97	1.12
	10–14 patients	675	244	-36.1	431	-63.9	1.38	1.22	1.56*	1.16	1.04	1.29*
	≥15 patients	172	43	-25	129	-75	1.62	1.37	1.92*	1.33	1.12	1.57*
	Un-known	149	74	-49.7	75	-50.3	1.09	0.9	1.32	1.13	0.96	1.32
Study time	0–30 min-utes per day	2,059	991	-48.1	1,068	51.9	1	Reference		1	Reference	
	31–60 min-utes per day	2,515	1,188	-47.2	1,327	-52.8	1.02	0.96	1.08	1	0.95	1.06
	61–90 min-utes per day	1,007	454	-45.1	553	-54.9	1.06	0.98	1.15	1	0.93	1.07
	≥91 min-utes per day	255	101	-39.6	154	-60.4	1.16	1.03	1.31*	1.03	0.92	1.14
	Un-known	213	107	-50.2	106	-49.8	0.96	0.84	1.1	0.96	0.86	1.08
Case conferences in a hospital	0 per week	990	493	-49.8	497	-50.2	1	Reference		1	Reference	
	1 per week	2,987	1,436	-48.1	1,551	-51.9	1.03	0.95	1.12	1	0.93	1.07
	2 per week	1,268	562	-44.3	706	-55.7	1.11	1	1.23*	1.05	0.97	1.14
	3 per week	348	145	-41.7	203	-58.3	1.16	1.02	1.32*	1.1	0.99	1.22
	4 per week	456	205	-45	251	-55	1.1	0.97	1.24	1.03	0.93	1.14

Table 2 (continued)

Resident variable		n	COVID-19 care no (%), n = 2841		yes (%), n = 3208		Univariable probability ratio	95%CI		Multivariable adjusted probability ratio	95%CI	
PPE supply status	Completely sufficient supply	2,844	1,253	-44.1	1,591	-55.9	1	Reference		1	Reference	
	Sufficient supply	2,228	1,090	-48.9	1,138	-51.1	0.91	0.86	0.94*	0.93	0.9	0.99*
	Neither	622	324	-52.1	298	-47.9	0.86	0.77	0.92*	0.89	0.84	0.998*
	Insufficient supply	295	139	-47.1	156	-52.9	0.95	0.83	0.93*	0.95	0.85	1.03
	Completely insufficient supply	60	35	-58.3	25	-41.7	0.75	0.54	1.02	0.88	0.69	1.13
Hospital variable												
Location	Rural area	4,048	2,241	-55.4	1,807	-44.6	1	Reference		1	Reference	
	Urban area	2,001	600	-30	1,401	-70	1.57	1.41	1.75*	1.25	1.14	1.38*
Region	Hokkaido	206	97	-47.1	109	-52.9	1	Reference		1	Reference	
	Tohoku	454	320	-70.5	134	-29.5	0.56	0.38	0.81*	0.87	0.6	1.26
	Kanto	1,751	556	-31.8	1,195	-68.2	1.29	1.07	1.56*	1.28	1.09	1.51*
	Chubu	907	445	-49.1	462	-50.9	0.96	0.77	1.2	1.08	0.9	1.3
	Kinki	1,353	517	-38.2	836	-61.8	1.17	0.97	1.41	1.22	1.03	1.45*
	Chugoku	389	284	-73	105	-27	0.51	0.35	0.74*	0.84	0.58	1.23
	Shikoku	232	184	-79.3	48	-20.7	0.39	0.28	0.55*	0.69	0.46	1.01
	Kyushyu/Okinawa	757	438	-57.9	319	-42.1	0.8	0.62	1.23	1	0.8	1.26
Epidemic area for COVID-19	Non-contaminated area	2,605	1,765	-67.8	840	-32.2	1	Reference		1	Reference	
	Contaminated area	3,444	1,076	-31.2	2,368	-68.8	2.13	1.86	2.44*	1.53	1.3	1.79*
Category of infectious disease designated medical institution	Specific-designated medical institutions for specified infectious diseases	4	3	-75	1	-25	1	Reference		1	Reference	
	Class 1-designated medical institutions for specified infectious diseases	570	280	-49.1	290	-50.9	2.04	0.25	16.4	2.92	0.35	24.78
	Class 2-designated medical institutions for specified infectious diseases	1,946	1,072	-55.1	874	-44.9	1.8	0.22	14.4	2.4	0.29	20.11

Table 2 (continued)

Resident variable		n	COVID-19 care		Univariable		Multivariable adjusted	
			no (%), n=2841	yes (%), n=3208	prob-ability ratio	95%CI	prob-ability ratio	95%CI
	Non-designated medical institutions for specified infectious diseases	3,529	1,486 -42.1	2,043 -57.9	2.32	0.29 18.5	2.55	0.3 21.37
Hospital function	Small and middle-sized hospital	1,325	644 -48.6	681 -51.4	1	Reference	1	Reference
	Advanced treatment hospital	712	411 -57.7	301 -42.3	0.82	0.63 1.08	0.86	0.71 1.04
	Regional medical care support hospital	4,012	1,786 -44.5	2,226 -55.5	1.08	0.95 1.23	1.08	0.99 1.18
University or community hospital	University	682	400 -58.7	282 -41.3	0.77	0.6 1	1	0.78 1.27
	University-branch hospital	312	89 -28.5	223 -71.5	1.34	1.17 1.53*	1.02	0.88 1.18
	Community hospital	5,055	2,352 -46.5	2,703 -53.5	1	Reference	1	Reference
Administration type	National hospital organization's hospital	260	160 -61.5	106 -40.8	1	Reference	1	Reference
	Japan community health care organization's hospital	60	12 -20	48 -80	2.01	1.28 3.16*	1.44	0.996 2.08
	Industrial accident compensation hospital	140	56 -40	84 -60	1.51	0.9 2.52	1.04	0.71 1.52
	Prefectural hospital	411	280 -68.1	131 -31.9	0.8	0.49 1.32	0.97	0.64 1.47
	Ordinance designated city hospital	161	52 -32.3	109 -67.7	1.7	1.11 2.61*	1.14	0.7 1.86
	Municipality-owned hospital	725	354 -48.8	371 -51.2	1.28	1.11 0.85	1.26	0.88 1.8
	Others	4,286	1,927 -45	2,359 -55	1.38	0.94 2.03	1.13	0.81 1.58

COVID-19 = coronavirus disease, PGY = post graduate year, PPE = personal protective equipment. $p < 0.05$

Multivariable model adjusted for resident and hospital variables

Resident variable: number of years since graduation, sex, hoped/preferred specialty, general medicine rotation, internal medicine rotation, emergency department duty per month, number of care patients, study time, frequency of case conferences, and PPE supply

Hospital variable: hospital location, hospital function, epidemic area for COVID-19, designated medical institutions for specified infectious diseases, urban or rural, university or community hospital, administration type

Table 3 Relationship between COVID-19 care and General Medicine In-Training examination score (univariable and multivariable-adjusted linear generalized estimating equations analysis)

			Univariable				Multivariable adjusted			
	COVID-19 care	Mean score	Score difference	95%CI		p-value	Score difference	95%CI		p-value
Total (score, 0–60)	no experience	28.85	reference				reference			
	experience	29.28	0.436	0.052	0.820	0.026*	0.242	-0.128	0.611	0.200
Medical Interview and Professionalism (score, 0–6)	no experience	2.89	reference				reference			
	experience	2.93	0.041	-0.027	0.109	0.230	0.008	-0.061	0.076	0.824
Symptomatology and Clinical Reasoning (score, 0–15)	no experience	8.54	Reference				reference			
	experience	8.66	0.120	0.001	0.238	0.047*	0.069	-0.049	0.187	0.254
Physical Examination and Clinical Procedures (score, 0–15)	no experience	6.71	reference				reference			
	experience	6.83	0.116	-0.01	0.243	0.072	0.061	-0.074	0.196	0.372
Disease Knowledge (score, 0–24)	no experience	10.70	reference				reference			
	experience	10.86	0.159	-0.04	0.358	0.120	0.104	-0.089	0.296	0.292
COVID-19 related question (score, 0–1)	no experience	0.80	reference				reference			
	experience	0.85	0.046	0.023	0.069	< 0.001*	0.026	0.003	0.049	0.028*

GM-ITE = general medicine in-training examination, COVID-19 = coronavirus disease, CI = confidence interval, * $p < 0.05$

Estimates of the coefficients of COVID-19 management experience in linear generalized estimating equation models, including hospitals as clusters with the independent working correlation structure. The interpretation of coefficients is the mean difference of scores (total score and scores in subject-specific areas) or difference in correct answer rates (COVID-19-related question)

Multivariable model adjusted for resident-level and hospital-level variables

Resident variable: number of years since graduation, sex, hoped/preferred specialty, general medicine rotation, internal medicine rotation, emergency department duty per month, number of care patients, study time, frequency of case conferences, and PPE supply

Hospital variable: hospital location, hospital function, epidemic area for COVID-19, designated medical institutions for specified infectious diseases, urban or rural, university or community hospital, administration type

an increasing number of resident physicians attempting it (data not shown); thus, the examination score is highly reliable.

However, the study has some limitations. First, we studied the relationship between the experience in caring for patients with COVID-19 and the resident physicians' General Medicine In-Training Examination score for only one year, that is, during the COVID-19 pandemic. The training environment for resident physicians has changed every year since the pandemic. Therefore, additional longitudinal analysis might highlight the effects of COVID-19 care and COVID-19-specific knowledge on some of the four categories, including medical interviews and professionalism, symptomatology and clinical reasoning, physical examination and clinical procedures, and disease knowledge. Second, this study did not include all the participants from training hospitals in Japan. Third, only one question in the study was related to the COVID-19. Fourth, our study has a cross-sectional design; thus, the results cannot explain the causal relationship between COVID-19 care and the score for the COVID-19-related question. Furthermore, this study could not identify a correlation between the number of experiences caring for patients with COVID-19 and the General Medicine

In-Training Examination score (sub-analysis finding, data not shown). Additionally, other aspects of the different services of care for patients with COVID-19 were not considered in this study.

Consequently, future studies are needed to clarify the appropriate number of experiences caring for patients with COVID-19 during residency training. A longitudinal study with more detailed questions on the experience of caring for patients with COVID-19 is required to contribute to COVID-19 residency training.

Conclusion

COVID-19 care provided by Japanese resident physicians did not affect the General Medicine In-Training Examination score; however, it did highlight an improvement in the score on the COVID-19-related question. Therefore, experience in caring for patients with COVID-19 is important for effective training in the management of COVID-19 infection.

Abbreviations
COVID-19   Coronavirus disease-2019
GM-ITE   General medicine in-training examination
JAMEP   Japan institute for advancement of medical educational
            program

PGY	Postgraduate year
PPE	Personal protective equipment
GEE	Generalized estimating equation
ED	Emergency room
CI	Confidence interval
GM	General Medicine
IM	Internal Medicine

Supplementary Information

Author contributions
S.N. and Y.N. had the original idea for the paper, which was further developed in discussions with A.G., M.I., K.S., K.K., T. Shimizu, Y. Y., S.F., and Y.T., and led the statistical analyses. T. Shinozaki contributed to the interpretation of findings and wrote the first draft of the manuscript. All the authors contributed to drafting the manuscript. All the authors have read and agreed to the published version of the manuscript.

Data availability
The data and materials will not be officially available because the informed consent of participants in each hospital does not permit such publication. The corresponding author will respond upon reasonable request.

Declarations

Ethics approval and consent to participate
All the procedures were followed in accordance with the Declaration of Helsinki. The study was approved by the ethics review board of the Japan Institute for Advancement of Medical Educational Program (JAMEP) (approval number 21 – 9). Written consent was obtained from participants to participate in this study.

Consent for publication
Not applicable.

Competing interests
K.S. of the authors is an Editorial Board Member. Y.N. received an honorarium from the Japan Institute for Advancement of Medical Education Program (JAMEP) as a GM-ITE project manager. Y.T. is the director of JAMEP; he and H.K. and K.S. received an honorarium from JAMEP for delivering lectures for the JAMEP. T.Shimizu, Y.Y., K.S., and S.F. received honoraria from JAMEP as exam preparers for the GM-ITE. S.N., M.H., A.G., M.I., T.Shinozaki., K.K., and S.F. have declared no competing interests.

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