
STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Owing to geographical constraints, almost all patients on Tarama Island were expected to attend Tarama Clinic; thus, the present research was a population-based study—even though Japan adopts a free-access system, whereby patients can visit any medical institution they wish.

⇒ The first author was the only physician on Tarama Island and lived together with all the residents in a small community, which contributed to close patient–physician relationships; it enabled the physician to obtain information about a wide variety of topics and highly personal information and to assess the Patient Centred Assessment Method more accurately.

⇒ We conducted this study at a single medical institution on a Japanese island, which limits the generalisability of the findings.

⇒ We excluded some patients and eligible participants from the study, and this may have resulted in bias.

ABSTRACT

Objectives  This study aimed to elucidate the relationship between patient complexity and healthcare costs in a primary care setting on a Japanese island.

Design  Cross-sectional study.

Setting  Tarama Clinic, Okinawa Miyako Hospital, on Tarama Island, Okinawa Prefecture, Japan.

Participants  Patients who visited Tarama Clinic from 1 April 2018 to 30 June 2018, were aged 20 years or above, were resident in Tarama Village and had decision-making capacity.

Outcome measures  Patient complexity scored using Patient Centred Assessment Method (PCAM), healthcare costs per person per year/visit and participant characteristics.

Results  We included 355 study participants. The means (SD) of the total PCAM scores and healthcare costs per person per year/visit were 21.4 (5.7) and 1056.4 (952.7)/125.7 (86.7) in US dollars, respectively. Spearman’s rank correlation coefficients between the total PCAM scores and healthcare costs per person per year/visit were 0.33 and 0.28 (p values <0.0001 and <0.0001), respectively. The healthcare costs per person tended to be relatively low in the patient groups with the highest complexity. In the groups, the proportion of those with psychological conditions tended to be higher and those with cardiovascular diseases tended to be lower than in the other groups. Multiple regression analysis showed that total PCAM scores were associated with healthcare costs per person per year/visit, which were log-transformed: the regression coefficients were 3.87×10^{-2} and 2.34×10^{-3}, respectively; the p values were <0.001 and <0.001, respectively.

Conclusions  This study clarified the association between patient complexity and healthcare costs in a primary care setting on a Japanese island. We found that such costs tended to be relatively low in patient groups with the highest complexity. In primary care, healthcare costs probably do not accurately reflect the value of services provided by medical institutions; it may be essential to introduce a system that provides incentives for problemsolving approaches to social issues.

INTRODUCTION

The social determinants of health (SDH) have attracted global attention since the late 1990s1; that development has elevated the importance of understanding the whole context of patients from biopsychological and social perspectives, as proposed by Engel.2 Over the past two decades, accumulated evidence suggests that SDH3 account for 30%–55% of health outcomes.3 According, multidimensional assessment from biopsychosocial perspectives is essential for improving health outcomes.

Owing to population ageing and increased economic inequality, the interplay of patients’ biopsychosocial factors has become increasingly complex. Globally, the population aged 65 years and over is growing4; as a result, there has been an increase in the number of patients with associated conditions, including multimorbidity,5–7 such mental disorders as dementia8,9 and depression,10 and social isolation.11 Additionally, income inequality is growing for over 70% of the global population.12 Therefore, identifying, assessing and dealing with patients’ problems from biopsychosocial perspectives is gaining significance—especially in primary care settings, which have a substantially wide scope of practice.13
The interplay of these biological, psychological and social factors is conceptualised as patient complexity; it is addressed by providing individualised attention to patient-specific sources of complexity. Various tools have been developed to identify and assess patient complexity, such as INTERMED, the Minnesota Complexity Assessment Method, and Patient Centred Assessment Method (PCAM). For example, in primary care settings, the PCAM allows healthcare providers to identify and assess patients’ problems from biopsychosocial perspectives and tackle those problems in order of priority based on severity and urgency level.

Global spending on health is increasing—especially among high-income countries; it is reportedly driven by technological change as well as the ageing population. Japan is facing drastic escalation in health spending. Thus, with rising medical costs, primary healthcare plays a significant role in maintaining the quality of medical care and controlling healthcare costs.

With population ageing, expanding inequality and rising medical costs, it is becoming increasingly important to deal with patients with complexities in primary care while taking into account the quality of medical care and healthcare costs. There is consistent evidence that multimorbidity (ie, part of biological complexity) is associated with increased healthcare costs; however, no research has clarified the relationship between patient complexity and such costs. This study aimed to elucidate the relationship between patient complexity and healthcare costs in a primary care setting on a Japanese island. It constitutes the first step in establishing evidence for primary care medical institutions to treat and care for patients with complexities efficiently and effectively—and how such treatment and care is reflected in healthcare costs.

METHODS
We analysed the data without missing values obtained in a previous study, which clarified the association between alcohol consumption/alcohol use disorders and patient complexity.

Study design
We conducted a cross-sectional study and report it in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Setting
We conducted this study at Tarama Clinic, Okinawa Miyako Hospital, on Tarama Island, Okinawa Prefecture, Japan. Tarama Island is located approximately 67 km west of Miyako Island, 125 min by ferry or 25 min by aeroplane; Miyako Island is located approximately 300 km southwest of Okinawa main island. Tarama Island is the main part of Tarama Village, whose population was 1194 (555 female, 639 male) in 2015. The proportion of the population then aged 65 years or older was 26.4%, which was close to the national average (26.6%). A greater proportion (41.6%) of the population in 2015 was engaged in primary industries (agriculture, forestry and fisheries) compared with the national average (3.8%). The average annual income was ¥1765 000/person (US$14575/person (US$1 = ¥121.1 in 2015)), which was lower than the national average (¥3 020 000/person (US$26 449/person)).

During the study period, Tarama Clinic had four staff (physician (the first author), nurse, nurse assistant and clerk) and provided general outpatient and 24-hour emergency services, that is, primary care services. It was the only medical institution on the island other than a dental clinic. We supposed that owing to geographical constraints, almost all patients on Tarama Island attended Tarama Clinic; thus, the present research was a population-based study—even though Japan adopts a free-access system, whereby patients can visit any medical institution they wish.

Participants
The participants were patients who visited Tarama Clinic from 1 April 2018 to 30 June 2018. Our inclusion criteria were as follows: aged 20 years or above; resident in Tarama Village; and having decision-making capacity. We excluded eligible patients who refused to participate in our previous study. Patients whose participation was judged to have an unfavourable influence on the patient–physician relationship were also excluded. The PCAM covered some sensitive areas, such as financial insecurity, which some patients may have considered psychologically invasive and could have impaired the patient–physician relationship. On the island, patients effectively had no alternative medical institution to Tarama Clinic. Thus, we carefully considered such relationships to avoid patients wishing to discontinue treatment or care. Patients were excluded if the physician was out of the office and informed consent was not obtained or if many patients were waiting to see the physician and obtaining informed consent interfered with usual medical practice.

The first author fully informed the patients of the purpose of our previous study, and those who agreed to participate provided written consent. Additionally, information regarding the conduct of this study was disclosed to all potential patients. They were also provided the opportunity to decline participation in the study.

Outcome measures
We collected the following data from 1 April 2018 to 31 March 2019.

Patient complexity scored using PCAM
The PCAM is a tool for assessing patient complexity from biopsychosocial perspectives. The PCAM has four domains: health and well-being; social environment; health literacy and communication; and service coordination. Each domain comprises two or four items: four in health and well-being (physical health needs, physical
health impacting on mental well-being, lifestyle impacting on physical or mental well-being and other mental well-being concerns; four in social environment (home environment, daily activities, social networks and financial resources); two in health literacy and communication (health literacy and engagement in discussion); and two in service coordination (other services and service coordination). 42 Each item comprises four categories: routine care, active monitoring, plan action and act now; 42 they have a scale of 1–4 according to increasing complexity. 43 Thus, the total PCAM score has a minimum of 12 and maximum of 48; the PCAM health and well-being/social environment domain scores have a minimum of 4 and maximum of 16; and the PCAM health literacy and communication/service coordination domain scores have a minimum of 2 and maximum of 8. In accordance with the PCAM User Guide for Conducting the Assessment, 44 the physician assessed the PCAM during or after consultation. There is no threshold for total PCAM scores. However, approximately 15% of patient–physician encounters are reportedly rated as difficult by physicians. 45 46 Thus, we divided the total PCAM scores into two categories: low and high complexity, which were designated as the ≤25 th and >25 th percentiles, respectively, of the total PCAM scores. Further, we categorised low complexity into four groups: low complexity 1, low complexity 2, low complexity 3 and low complexity 4, which we designated as the ≤25 th, >25 th and ≤50 th, >50 th and ≤75 th, and >75 th percentiles, respectively, of low complexity. We categorised high complexity into four groups: high complexity 1, high complexity 2, high complexity 3 and high complexity 4, which we designated as the ≤25 th, >25 th and ≤50 th, >50 th and ≤75 th, and >75 th percentiles, respectively, of high complexity.

There is also no threshold for PCAM domain scores. Additionally, there are no other rough standards for the PCAM domain scores, such as the proportion of difficult patient-physician encounters for the total PCAM scores, and the range of the PCAM domain scores is relatively narrow compared with the total PCAM scores: a minimum of 4 and maximum of 16, or a minimum of 2 and maximum of 8. Therefore, we did not divide and categorise the PCAM domain scores in the same manner as the total PCAM scores.

Healthcare costs per person per year/visit
We calculated the patients’ healthcare costs for the previous year (1 April 2017 to 31 March 2018) using medical fee receipts, which are invoices issued by a medical institution to a public medical insurer. 47 Those invoices include information about medical procedures (such as examinations and tests), prescribed medications and medical fees. 47 We also determined the healthcare costs per person per visit by dividing the annual healthcare costs per person by the number of patient visits. Healthcare costs per person per year/visit were expressed in US dollars; the exchange rate (annual average) against the dollar in 2017 was US$1=¥112.1. 48

In this study, to minimise variability in the healthcare costs measured, we did not use the costs of the visit when the PCAM score was collected. The healthcare costs, which were measured just one time, would have varied widely from situation to situation. For example, if a patient had a chief complaint that they do not usually have, extra examinations such as blood tests or X-ray examination would have raised the healthcare costs at that time. To minimise variability, we used the sum of the healthcare costs for 1 year (the healthcare costs per person per year) and its average (the healthcare costs per person per visit).

We focused on the healthcare costs in primary care and did not consider the healthcare costs for patients that were transferred to other healthcare providers. This is because, if transferred to other healthcare providers located off the island, patients were usually transferred to a hospital that provided secondary or tertiary care; their healthcare costs were included with those in secondary or tertiary care but not in primary care.

Participant characteristics
We obtained patients’ age, sex and condition from medical records. We categorised age into three groups: <60 years, 60–79 years and ≥80 years. We classified diseases into the following 16 chapters of the International Classification of Primary Care, second edition (ICPC-2): general and unspecified; blood, blood forming organs and immune mechanism; digestive; eye; ear; cardiovascular; musculoskeletal; neurological; psychological; respiratory; skin; endocrine/metabolic and nutritional; urological; pregnancy, childbearing, family planning; genital (female genital and male genital) and social problems. 49 We combined the ICPC-2 female and male genital system chapters because they include the same body systems.

We obtained the following data using self-administered questionnaires: marital status (married, single or divorced or widowed); living status (not living alone or living alone); education (up to elementary or junior high school, up to high school or junior high school under the old system (equivalent to high school under the current system), or up to vocational school, junior college, technical school, university, college, graduate school or other); work status (working or not working); physical activity (exercising or not exercising); smoking status (ex-smoker/never-smoker or current smoker) and alcohol intake (no problematic drinking or problematic drinking). If necessary, a nurse helped patients complete the questionnaire. We defined ‘working’ as full-time or part-time work as well as housewives or househusbands; we defined ‘not working’ as individuals out of work. We defined ‘exercising’ as engaging in physical activity for over half an hour twice-weekly for 1 year or more. We defined ‘problematic drinking’ as a score of 12 points or more with the Alcohol Use Disorders Identification Test. 50 51 We obtained public assistance data (not receiving or receiving) from medical fee receipts.

Statistical analysis
We performed the following descriptive analysis: participant characteristics; distribution of total PCAM scores; distribution of healthcare costs per person per year/visit; relationship between total PCAM scores and healthcare costs per person per year/visit; healthcare costs per person per year in the low and high complexity groups; healthcare costs per person per visit in the low and high complexity groups; healthcare costs per person per year/visit and PCAM domain (health and well-being, social environment, health literacy and communication, and service coordination) scores; and participant characteristics in the low and high complexity groups. We calculated Spearman’s rank correlation coefficients in terms of the relationship between the total PCAM scores and healthcare costs per person per year/visit. Descriptive data are expressed as means (SD) for continuous variables and count (percentage) for categorical variables.

We performed multiple regression analysis on the association between the total PCAM scores and healthcare costs per person per year/visit. We used the healthcare costs per person per year/visit as dependent variables; we employed the total PCAM scores, age group and sex as independent variables. We did not use marital status, living status, education, work status, public assistance, physical activity, smoking status, alcohol intake and patients’ condition as independent variables. This is because these variables had been assessed in the PCAM and their effect had been included in the total PCAM scores: marital status, living status, work status and public assistance were assessed and included in the social environment domain; education in the health literacy and communication domain; and physical activity, smoking status, alcohol intake, and patients’ condition in the health and well-being domain. We conducted residual analysis using residual and quantile-quantile plots to verify that the model assumptions were met. If the residual analysis indicated that the model assumptions were not met, we used instead log-transformed dependent variables and repeated the residual analysis.

We performed descriptive analysis and multiple regression analysis using STATA/MP V.17.0. P values of <0.05 were considered statistically significant.

Sample size
We used the data collected in a previous study, which describes the sample size calculation.

Patient and public involvement
This study was conducted without patient or public involvement.

RESULTS
Among 521 patients who visited Tarama Clinic from 1 April 2018 to 30 June 2018, 95 did not meet the eligibility criteria: 57 were aged under 20 years; 13 were not resident in Tarama Village and 25 lacked decision-making capacity. Among the 426 eligible participants, we excluded 71: 28 refused to participate in our previous study; in nine, participation was judged to have an unfavourable influence on the patient-physician relationship; informed consent was not obtained from two because the physician was out of the office; and informed consent was not obtained from 32 because many patients were waiting to see the physician (figure 1). As a result, we included 355 study participants in this study. The participant characteristics appear in table 1.

The total PCAM scores and healthcare costs per person per year/visit appear in figures 2 and 3. The means (SDs) of the total PCAM scores and healthcare costs per person per year/visit were 21.4 (5.7) and 1056.4 (952.7)/125.7...
(86.7) in US dollars, respectively. We designated the low complexity 1, low complexity 2, low complexity 3 and low complexity 4 groups as ≤17 (n=106), >17 and ≤19 (n=58), >19 and ≤22 (n=70), and >22 and ≤27 (n=71) of the PCAM total scores, respectively. We designated the high complexity 1, high complexity 2, high complexity 3 and high complexity 4 groups as >27 and ≤29 (n=16), >29 and ≤31 (n=11), >31 and ≤33 (n=10) and >33 (n=13) of the PCAM total scores, respectively.

**Figure 2** Distribution of total PCAM scores. This figure is modified from Sugiyama et al.\(^\text{24}\) PCAM, Patient Centred Assessment Method.

**Figure 3** Distribution of healthcare costs per person per year/visit.

**Figure 4** shows relationship between the total PCAM scores and healthcare costs per person per year/visit. Spearmann’s rank correlation coefficients were 0.33 and 0.28 (Pvalues<0.0001 and <0.0001), respectively.

![Figure 2](https://example.com/figure2.png)

![Figure 3](https://example.com/figure3.png)

Figure 5 shows the healthcare costs per person per year in the low and high complexity groups and healthcare costs per person per visit in the low and high complexity groups. The healthcare costs per person tended to be relatively low in the patient groups with the highest complexity.

The participant characteristics in the low and high complexity groups appear in online supplemental table S1. In the patient groups with the highest complexity, the proportion of those with psychological conditions tended to be higher and those with cardiovascular diseases tended to be lower than in the other groups.

Online supplemental figures S1–S4 show healthcare costs per person per year/visit and PCAM domain scores. The healthcare costs per person tended to be relatively low in the patients with high PCAM health and well-being domain scores of 15 or 16. These costs tended to decrease gradually with higher PCAM social environment domain scores of 10 to 12. The costs did not show these tendencies with PCAM health literacy and communication/service coordination domain scores.

We performed multiple regression analysis on the association between total PCAM scores and healthcare costs per person per year/visit, and we used healthcare costs per person per year/visit as dependent variables. However, the residual analysis did not indicate that the model assumptions were met; thus, we applied log-transformed dependent variables instead. Multiple regression analysis showed that total PCAM scores were associated with healthcare costs per person per year/visit, which were log-transformed (table 2): the regression coefficients were $3.87 \times 10^{-2}$ and $2.34 \times 10^{-2}$, respectively; the p values were <0.001 and <0.001, respectively.

**DISCUSSION**

This study clarified the association between patient complexity and healthcare costs in a primary care setting on a Japanese island. We found that such costs tended to be relatively low in patient groups with the highest complexity.

Healthcare costs may directly result from patients' biological and psychological problems and indirectly from social problems. The number of chronic conditions (i.e., part of biopsychological problems) is reportedly associated with healthcare costs; that association could have influenced our results. However, the number of chronic conditions does not only reflect patients' biological and psychological problems; it also reflects social problems via the interlinking mechanisms from social conditions down to biological and psychological problems. Thus, it is reasonable to infer that biopsychological problems (or patient complexity) are associated with healthcare costs.

It was interesting to observe the association between patient complexity and healthcare costs in a clinic on a Japanese island. In Japan, healthcare costs in primary care are mainly based on a fee-for-service system. When medical services such as treatment, examinations and surgical procedure are provided through the insurance system, the provider is then reimbursed for the service in the fee-for-service system. Medical services are provided for biomedical and psychological problems; therefore, healthcare costs reflect biological and psychological problems. The PCAM assesses patient complexity from biopsychosocial perspectives; however, only its health and well-being domain assesses biological and psychological problems. That domain comprises only 4 among the total 12 items and accounts for a relatively small proportion of the total PCAM scores. The causal relationship between patient complexity (especially social problems) and healthcare costs is presumed to be remote; thus, it would have been difficult for us to identify that association. In this study, the first author was the only physician on Tarama Island and lived together with all the residents in a small community, which contributed to close patient–physician relationships. It enabled the physician to obtain information about a wide variety of topics and highly personal information and to assess the PCAM (especially social problems) more accurately. Thus, this situation and the population-based estimates owing to geographic
constraints may have enabled this study to identify the above association.

We did find a positive association between patient complexity and healthcare costs; however, healthcare costs tended to be relatively low in the patient groups with the highest complexity. The proportion of patients with psychological conditions tended to be higher and those with cardiovascular diseases tended to be lower. The inconsistency between patient complexity and healthcare costs here may have been caused by some patients with a single psychiatric disorder having a major impact on biopsychosocial aspects (such as alcohol dependency or mild intellectual disability) but few physical diseases or chronic conditions (such as cardiovascular diseases). Owing to psychiatric disorder, such patients are likely to suffer from poor mental well-being, or have health literacy and communication problems. They are also prone to develop social problems, such as unemployment, social isolation and financial insecurity, in addition to barriers to accessing healthcare. Accordingly, these conditions increase psychological and social complexity over a broad range of the PCAM domains: part of the health and well-being domain (fourth item) and all of the social environment, health literacy and communication, and service coordination domains.

Conversely, the PCAM assesses biological complexity in terms of symptoms or problems that require further investigation, physical health problems that impact on mental well-being, and lifestyle behaviour, such as alcohol, drugs, diet and exercise (first three items in the health and well-being domain). Thus, the PCAM does not necessarily assess biological complexity based on the number of physical diseases or chronic conditions but on undiagnosed conditions, influence on mental status, and behavioural risk factors. Therefore, even though some patients had few physical diseases or chronic conditions, they could well have had high biological complexity. Accordingly, some patients with a single psychiatric disorder (such as

**Figure 5** Healthcare costs per person per year in the low and high complexity groups and healthcare costs per person per visit in the low and high complexity groups. Figures in the columns show the mean values and error bars indicate 95% CIs. We designated the low complexity 1, low complexity 2, low complexity 3 and low complexity 4 groups as ≤17, >17 and ≤19, >19 and ≤22, and >22 and ≤27 of the Patient Centred Assessment Method (PCAM) total scores, respectively. We designated the high complexity 1, high complexity 2, high complexity 3 and high complexity 4 groups as >27 and ≤29, >29 and ≤31, >31 and ≤33, and >33 of the PCAM total scores, respectively.
alcohol dependency or mild intellectual disability) had extremely high biopsychosocial complexity but few physical diseases or chronic conditions; thus, they could have had relatively low healthcare costs.

Furthermore, focusing on the association between PCAM health and well-being domain scores and healthcare costs, we found the same tendency as the relatively low healthcare costs found in the patient groups with the highest complexity, which could likewise be explained by some patients with a single psychiatric disorder having extremely high biopsychosocial complexity but few physical diseases or chronic conditions. We also found a similar tendency in the association between PCAM social environment domain scores and healthcare costs. However, the domain scores, which were originally supposed to range up to 16, only had a maximum of 12 and the healthcare costs gradually decreased with domain scores of 10 or more. The reason is probably that the patient groups with the highest complexity and relatively low healthcare costs, who were supposed to have higher PCAM social environment domain scores than other groups, did not have higher scores in this domain, which mitigated the sharp drop found with PCAM health and well-being domain scores. This could have several reasons. First, Japan is one of the safest countries in the world, which could have lowered home environment item scores. Second, in a small community on a Japanese island, social participation is presumably forced through stronger peer pressure than in urban areas. The forced social participation may have had an effect on patients' social networks, leading to low social networks item scores. Third, Japan has universal health coverage, including its universal health insurance system. These systems prevent financial insecurity, resulting in low financial resources item scores. We did not find the tendency in the association between PCAM health literacy and communication/service coordination domains scores and healthcare costs because the ranges

<table>
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<th>Table 2</th>
<th>Multiple regression analysis on the association between total PCAM scores and healthcare costs per person per year/visit</th>
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<tr>
<td></td>
<td>Model 1: Healthcare costs per person per year (log-transformed)</td>
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<tr>
<td></td>
<td>Regression coefficient</td>
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<tr>
<td>Total PCAM scores</td>
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<td>≥80 years</td>
<td>6.09×10(^{-1})</td>
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<tr>
<td>Model 2: Healthcare costs per person per visit (log-transformed)</td>
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<td>Regression coefficient</td>
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<tr>
<td>Total PCAM scores</td>
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<td>&lt;60 years</td>
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<td>2.08×10(^{-1})</td>
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<td>≥80 years</td>
<td>2.41×10(^{-1})</td>
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of these domain scores are narrow and the influence of the patient groups with the highest complexity and relatively low healthcare costs appeared to have dissipated.

Another reason for our inconsistent results is that this study was conducted in a primary care setting on a Japanese island; patients with high complexity and high healthcare costs may not have been resident there. Patients highly dependent on medical or nursing services (such as those with terminal cancer or advanced dementia) or highly dependent on advanced medical services (such as those requiring dialysis or intubation) did not live on the island: they would have been forced to move away owing to the lack of adequate services. Such patients would have had high complexity and high medical expenses. In Japan, those patients are usually treated outside primary care outpatient settings; they are treated at institutions that provide appropriate services, such as elderly care homes with home medical care, or at secondary care hospitals. With respect to primary care outpatient settings, the results of this study are presumably valid.

It was unclear whether treatment and care were provided efficiently and effectively according to the degree of patient complexity: this study did not measure consultation time or clinical outcomes. However, intervention may not have been properly provided to the patient groups with the highest complexity as evidenced by the relatively low healthcare costs. This may have been partly due to the functional limitations of medical institutions in meeting a broad range of patients’ needs. Especially in patients with very high complexity, primary care providers need to make referrals to a wide range of services (including appropriate medical, nursing and welfare services); therefore, the value of interprofessional collaboration cannot be over emphasised. Social prescription is also an important option for primary care providers in delivering individualised care for a broad range of patients’ needs. Thus, in primary care, which needs to deal with a wide variety of issues, including social problems, healthcare costs probably do not accurately reflect the value of services provided by medical institutions; a fee-for-service system, which simply addresses biomedical and psychological problems, may be inappropriate. Considering that awareness about the importance of SDH is growing and patient complexity is increasing owing to population ageing and increased economic inequality, it may be essential to introduce a system that not only addresses biological and psychological issues but provides incentives for problem-solving approaches to social issues.

This study has several limitations. First, we conducted this study at a single medical institution on a Japanese island, which limits the generalisability of the findings; thus, further multicentre studies are warranted. Second, we excluded some patients and eligible participants from the study, and this may have resulted in bias. We excluded 25 patients who lacked decision-making capacity; the main reason was cognitive impairment. However, they may have had relatively low patient complexity. They could continue living on the island despite their cognitive impairment and the lack of services: they were presumed to be biopsychosocially stable. Therefore, the sampling restrictions may have had a limited effect on our inconsistent results. We also excluded nine eligible participants because we judged their participation would have an unfavourable influence on the patient–physician relationship. Among them, some patients had confirmed or suspected mental or personality disorders, which is likely to lead to high patient complexity. If such patients were socially isolated, Tarama Clinic was one of their few connections to a public institution. Furthermore, if those patients had little reason to visit Tarama Clinic (such as few prescriptions or tests), we excluded them from the study owing to the risk of losing the connection between them and the clinic. Excluding such patients could have influenced the study results. However, given their little reason to visit to the clinic, their healthcare costs would have been low. If they had been included in patient groups with the highest complexity, the inconsistent results may have been underestimated. Otherwise, the inconsistent results may have been overestimated. We excluded 34 eligible participants owing to lack of informed consent because the physician was out of the office and many patients were waiting to see the physician. Those patients visited Tarama Clinic only once during the registration period; the purpose of their visits was usually mild acute diseases, such as upper respiratory tract inflammation and gastroenteritis. They were otherwise healthy, which means they were likely to have had low complexity. Thus, excluding them may have had limited influence on our inconsistent results. Third, we defined the healthcare costs per person per year as the patients’ healthcare costs for the previous year. Thus, this study may not be a cross-sectional study in a strict sense. However, in Japan, 1 year does not make a large difference in healthcare costs. Therefore, a year is considered a relatively short period against changes in healthcare costs, which ensures that this study was a cross-sectional study.

**CONCLUSION**

This study clarified the association between patient complexity and healthcare costs in a primary care setting on a Japanese island. We found that such costs tended to be relatively low in patient groups with the highest complexity. In primary care, healthcare costs probably do not accurately reflect the value of services provided by medical institutions; it may be essential to introduce a system that provides incentives for problem-solving approaches to social issues.

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**Contributors** YS designed the study, analysed and interpreted the data, and drafted and revised the manuscript. RM and MM designed the study, interpreted the data and reviewed the manuscript. All the authors read and approved the final version of the manuscript. YS is responsible for the overall content as guarantor.
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**Competing interests** MM’s son-in-law worked at IOVA Services Japan K.K., which is a contract research organisation and contract sales organisation. MM’s son-in-law works at Synnos Health Clinical K.K., which is a contract research organisation and contract sales organisation. The other authors declare that they have no competing interests.

**Patient and public involvement** Patients and/or the public were not involved in the design, conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Not applicable.

**Ethics approval** This study was approved by the Ethics Committee of the Jikei University School of Medicine (acceptance number: 33-338 (10691)) and the Ethics Committee of Okinawa Miyako Hospital (approved on 22 March 2022). Information regarding the conduct of this study was disclosed to all potential patients. They were also provided the opportunity to decline participation in the study.

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**Data availability statement** No data are available.

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