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EXPERT REVIEW

Diagnostic imaging in Chile: population-based description of its use in hospitalized patients

Imágenes diagnósticas en Chile: descripción poblacional sobre su uso en pacientes hospitalizados

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Abstract

Introduction: *The limited availability of data in Chile on the use of diagnostic images (DI) poses a challenge in the efficient management of resources.* **Objective:** *To quantify and characterize the use of DI in hospitalized subjects in Chile for 1 year.* **Method:** *Descriptive population based study on the use of DI in Chile during 2019 in hospitalized subjects using an official national database recorded with the diagnosis-related groups (DRG) system. Demographic variables related to hospitalization and derived from the DRG were analyzed.* **Results:** *55.5% of hospital events involved at least one DI (n = 466,306). The most used imaging technique was radiography/X-ray (36.4%), followed by computed tomography (35%). The Magallanes and Aysén regions exhibited the highest DI rates. Hospitalized patients who required some DI had an average of days of hospitalization and mortality rate that were 3.4 and 5.5 times greater than those who did not require DI (p < 0.01).* **Conclusions:** *There are important geographical differences in the use of DI in Chile. Our description will facilitate future studies that delve deeper and explore access or socioeconomic differences.*

Keywords: *Epidemiology. Diagnostic Imaging. Hospitalization. Length of stay.*

Resumen

Introducción: *La escasa disponibilidad de datos en Chile sobre el uso de imágenes diagnósticas (ID) plantea un desafío en la gestión eficiente de recursos.* **Objetivo:** *Cuantificar y caracterizar el uso de ID en sujetos hospitalizados en Chile durante 1 año.* **Método:** *Estudio poblacional descriptivo sobre el uso de ID en Chile durante el año 2019 en sujetos hospitalizados utilizando una base de datos nacional oficial consignada con la herramienta de grupos relacionados a diagnósticos (GRD). Se analizaron variables demográficas, relativas a la hospitalización y derivadas de los GRD.* **Resultados:** *El 55,5% de los eventos hospitalarios involucró al menos una ID (n = 466.306). La modalidad de imagen más utilizada fue la radiografía (36,4%), seguida por la tomografía computada (35%). Las regiones de Magallanes y Aysén exhibieron las tasas de ID más altas. Los pacientes hospitalizados que requirieron alguna ID obtuvieron unos promedios de días de hospitalización y letalidad 3,4 y 5,5 veces mayores que los que no requirieron ID (p < 0,01).* **Conclusiones:** *Existen importantes diferencias geográficas en la utilización de ID en Chile. Nuestra descripción facilitará la realización de futuros estudios que profundicen y exploren las diferencias en el acceso o socioeconómicas.*

Palabras clave: *Epidemiología. Imágenes diagnósticas. Hospitalización. Duración de estadía.*

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Introduction

Technology is described as a positive determinant of health expenditure for a country according to the Organization for Economic Cooperation and Development (OECD), that is, it increases the costs of a nation's budget with the possibility of improvements in the quality or access to the health system[1]. Diagnostic imaging (DI), in its different modalities, has been an important area of technological development in recent decades. With them it is possible to make more accurate and timely diagnoses for the care of people, which avoids exposing patients to unnecessary treatments or surgeries that can lead to adverse effects or even death. In fact, there are studies that have estimated benefit-risk ratios for different examinations, such as the use of positron emission tomography with fluorodeoxyglucose in patients with suspected non-small cell lung cancer (ratio of 36:1) to avoid operative and perioperative risk, and for screening patients with breast cancer with mammography (ratio 4.6:1)[2].

The availability and number of examinations has grown rapidly in most OECD countries in the last two decades, with the United States of America being the country with the highest number of annual computed tomography (CT) examinations performed in 2021, with 84.5 million, 2.4 times higher than in 2001[3]. Although Chile is part of the OECD, the data provided by this organization is irregular, since several years are reported with missing data, which makes its analysis difficult and does not provide a complete description of the issue.

There is no general guideline or international reference on the optimal number or rate of annual DIs; however, they determine an indicator of health care quality in the aspect of accessibility and opportunity[4]. On the other hand, excessive use can lead to excessive health expenditure that would have no benefits for the population, and could even be harmful by increasing the exposure doses to ionizing radiation, with CT being the largest source of artificial radiation[5].

There are multiple international works that have described trends in the utilization of DI in various countries, some comparing the first two decades of this century[6-11]. These have provided relevant data on the age, geographic and socioeconomic distribution of DIs and their growing use.

In Chile, the evidence is scarce and there are only a few works that have used the variable "DRG weight" (diagnosis related groups) as an estimator of hospital complexity, or series of hospital discharges in which the different discharge variables coded using DRG are described in general[12-15]. Since 2019, there is open data available in FONASA (*Fondo Nacional de Salud* – Chile's national health system) corresponding to the annual hospital discharges of 65 hospitals that receive financing through the DRG system, which represent close to 85% of the country's hospital discharges and contain information about the procedures performed on each patient, including the DI[16,17]. DRGs are a hospital financing mechanism that facilitates resource management through indicators and metrics. In practice, using *software* trained with official hospital data, discharges are grouped according to the reason for admission, assigning each group a different DRG code. For example, a hospitalization for acute appendicitis will have a different code than one for a cerebral infarction, which allows similar events to be grouped into a same group. Furthermore, depending on the days of hospitalization, the interventions performed and other variables, a measure called "DRG weight" is given to each hospitalization, which is dimensionless and proportional to its complexity.

In this context, the objective of the present study is to quantify and characterize, based on the epidemiological variables place and person, the use of DI in subjects hospitalized in Chile during 1 year.

Method

Descriptive population-based study on the quantification and characterization of DI use in Chile during 2019 in hospitalized subjects.

Official databases of hospital discharges recorded through the DRG tool published by FONASA were used. The year 2019 was chosen because it was the first year in which this database was officially available for public use and to avoid confusing elements due to the COVID-19 pandemic.

The database unit of analysis corresponds to hospital events of the FONASA beneficiary population. It includes sociodemographic variables (gender, age, place of residence, among others), variables related to hospitalization (days of stay, clinical service), 35 diagnostic variables coded with the International Classification of Diseases, 10th edition (ICD-10), 30 procedural variables identified with ICD-9 and variables related to the type of DRG.

The data was analyzed using SPSS software version 25.0 (Illinois, USA). The variables used were gender, age, discharge condition, hospital stay, health

Table 1. Most frequent imaging examinations according to the type of technique

XR		US		CT		MRI	
Type	n (%)	Type	n (%)	Type	n (%)	Type	n (%)
Chest	165,690 (55)	Echocardiography	52,655 (24)	Abdomen	85,252 (29)	Brain and brainstem	10,514 (48.9)
Extremities and pelvis	62,812 (21)	Ultrasound of pregnant uterus	48,916 (23)	Head and neck	78,511 (27)	Abdomen, head, neck and eye-sockets	7,061 (32.8)
Contrasted arteriography	21,994 (7)	Abdomen and retroperitoneum ultrasound	44,864 (21)	Chest	58,661 (20)	Spine	2,571 (12)
Contrasted angiocardiography	20,709 (7)	Urinary system ultrasound	15,642 (7)	Urological	13,381 (5)	Musculoskeletal	576 (2.7)
Abdomen	13,216 (4)	Head and neck ultrasound	12,412 (6)	Others	55,209 (19)	Pelvis, prostate and bladder	544 (2.5)
Others	18,045 (6)	Others	42,102 (19)			Others	240 (1.1)
Total (%)	302,466 (36.4)		216,591 (26)		291,014 (35)		21,506 (2.6)

MRI: magnetic resonance imaging; XR: radiography/X-ray; CT: computed tomography; US: ultrasound.
The count and percentage of the most frequent imaging examinations according to the technique with respect to the total are indicated.

service (HS) which refers to a geographic area, type of admission, DRG weight and procedures. The DRG weight variable is dimensionless and translates the complexity and thus the cost of the hospital event, in proportion to an average event to which the value of 1 is assigned. This variable allows the resources of the public health system to be distributed not only according to the fixed costs of each HS, but also according to the complexity and needs of the people it looks after.

Using the procedure codes defined according to the ICD-9 CM included in the sections of

«Diagnostic radiology» (87) and «Other radiodiagnostic and related techniques» (88), diagnostic images were classified by type of technique into radiography/X-ray (XR), ultrasound (US), computed tomography (CT) and magnetic resonance imaging (MRI).

Overall DI rates were estimated and according to the type of technique carried out in each HS per 100 members. The rates were calculated having as the numerator the total number of examinations performed, and according to each type of technique with the total population assigned to each HS provided by FONASA on its website as the denominator[18]. Rates were then standardized by indirect method with the national average creating standardized ratios of DI per HS. In the same way, average weight rates per HS adjusted by the national average were calculated. For the HS that obtained rates that were more different to the national average, a Student's t-test for one sample was performed comparing the average number of DIs performed in each hospitalization in said HS with the previously calculated national average.

To evaluate differences according to age, ages were grouped into sections. With this, overall DI rates were calculated and according to the type of technique by age group, with the number of examinations as numerator and the total number of expenses for each age group as denominator.

In order to demonstrate plausible associations, patients were grouped into two groups according to whether or not they underwent any DI during hospitalization. Using Student's t and chi square statistical tests, significant differences were sought between the groups according to the variables gender, DI, days of hospitalization, discharge condition and DRG weight.

The information used corresponded to official data sources that do not allow the identification of individuals, so the provisions of Law 19,628 regarding the protection of privacy and the use of sensitive data in Chile were not violated.

Results

Of the total hospital discharges, 55.5% underwent some DI (n = 466,306). 54% were women (n = 253,523) and the average age was 45.6 years (range: 0-118).

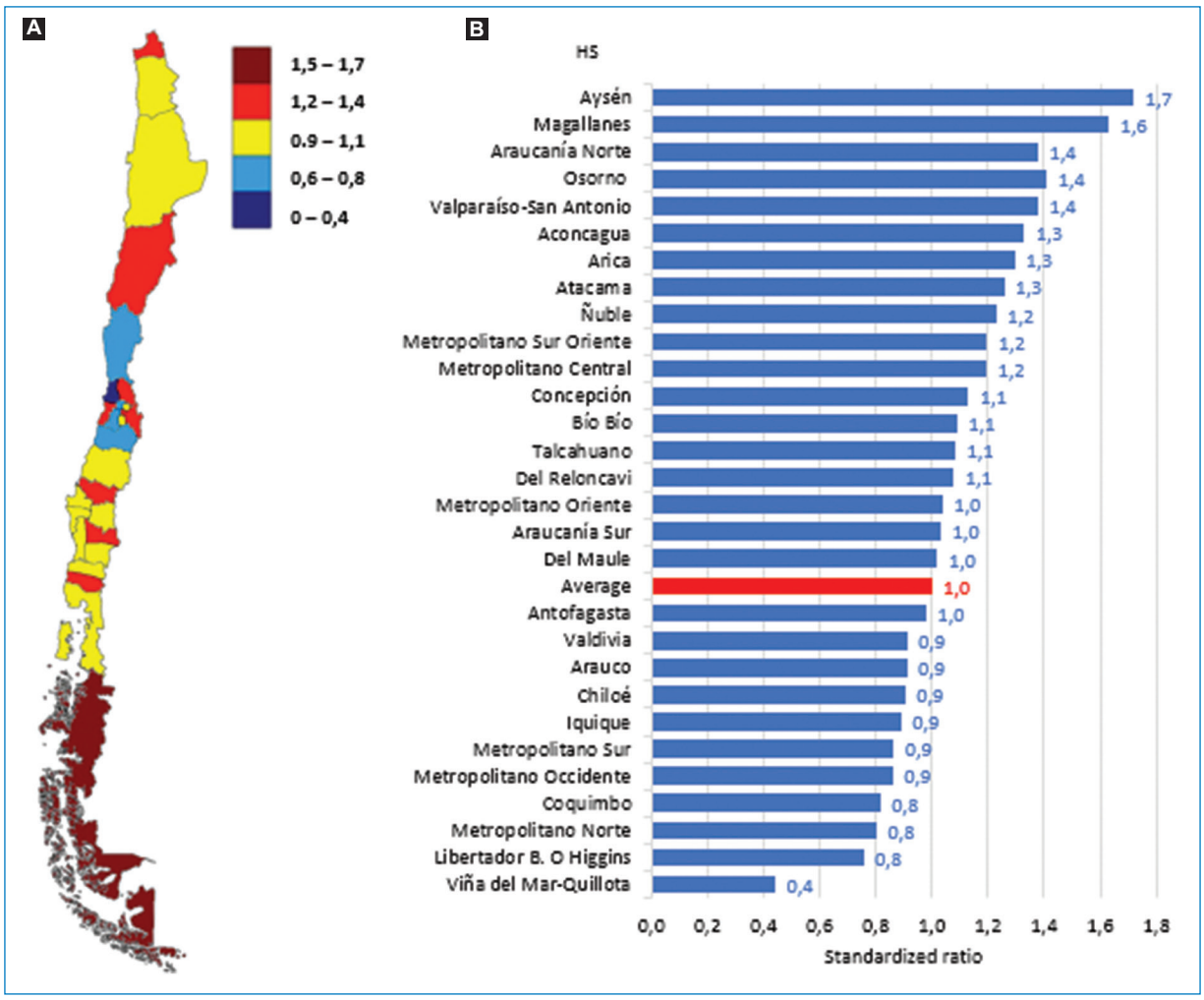

Figure 1. Standardized ratio of overall diagnostic images (DI) according to health service (HS). Geographic distribution **(A)** and graph **(B)** of the standardized ratio of DI according to each HS.

The specialties in charge of patients who underwent DI were mostly internal medicine (21%), general surgery (16%), gynecology and obstetrics (14%), pediatrics (10%) and traumatology (9%). 76% were admitted to hospital from the emergency department; only 12% were scheduled admissions and the same percentage for those of obstetric origin.

A total of 831,577 examinations were recorded, of which 36.4% corresponded to XR, 26% to US, 35% to CT and 2.6% to MRI. The most frequent examinations by imaging technique are detailed in table 1.

The standardized ratio of overall DIs and by imaging technique according to HS are shown in Figs. 1 and 2, respectively. The HS with the lowest standardized rate was Viña del Mar-Quillota, with a ratio 60% lower than the national average, while Magallanes and Aysén obtained ratios 60% and 70% higher, respectively. In the same order, they obtained an average DI per hospitalization of 0.38, 1.09 and 0.99, respectively; these averages demonstrated significant differences with respect to the national average (0.79) in the one-sample Student t-test ($p < 0.01$).

Regarding the DRG weight variable, an average of 0.846 (95% CI: 0.844-0.848) and a median of 0.626 was obtained for the total discharges. Table 2 shows the HS with the highest and lowest total weights, with their respective average weights. Fig. 3 demonstrates the standardized ratio of the DRG weight rate per beneficiary population according to HS.

When hospitalized patients were separated into two groups depending on whether or not they underwent DI, those who did had an average DRG weight 1.6 times greater (0.665 vs. 1.072), an average number of days of hospitalization 3.43 times higher (2.53 vs. 8.70) and a mortality rate 5.5 times higher (0.87% vs.

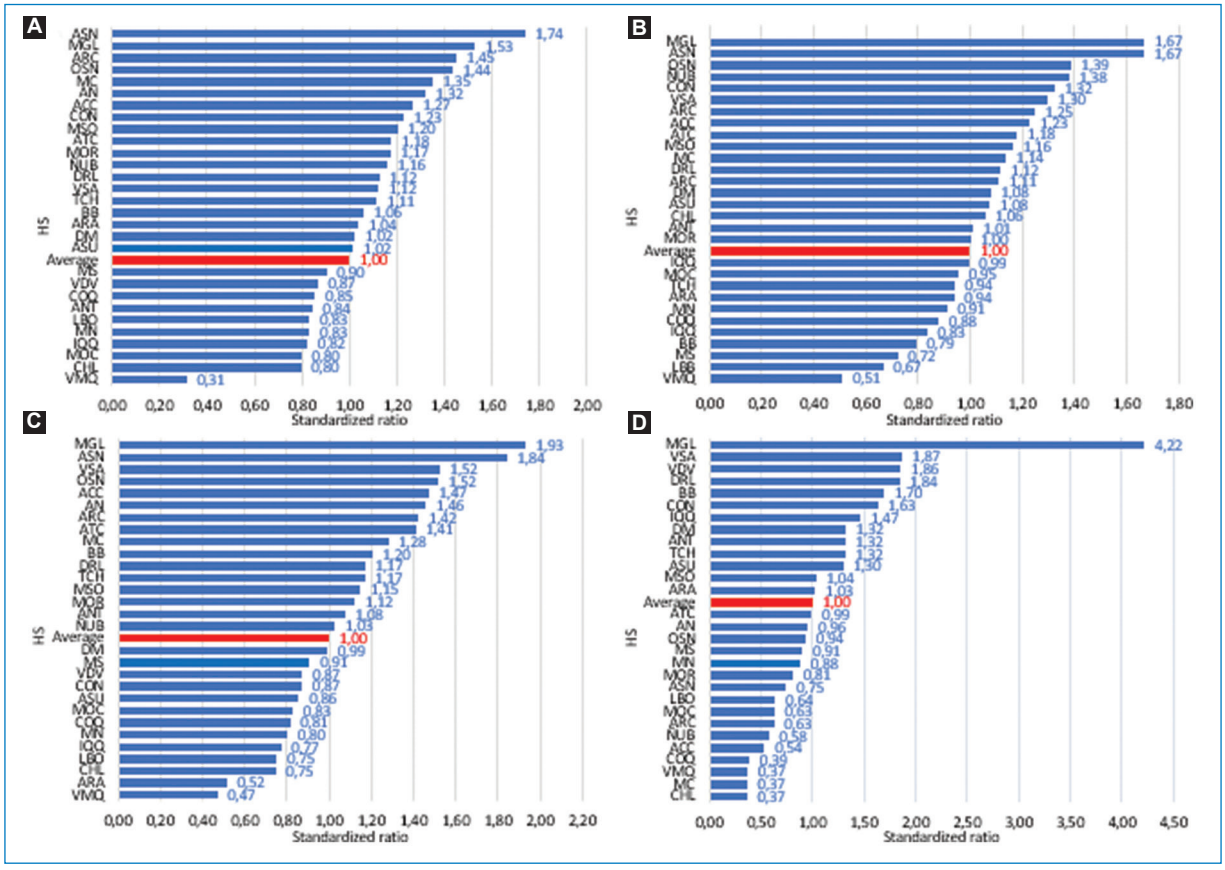

Figure 2. Standardized ratio of diagnostic images according to technique. **A:** x-ray. **B:** ultrasound. **C:** computed tomography. **D:** MRI. ACC: Aconcagua; AN: Araucanía Norte; ANT: Antofagasta; ARA: Arauco; ARC: Arica; ASN: Aysén; ASU: Araucanía Sur; ATC: Atacama; BB: Bío-Bío; CHL: Chiloé; CON: Conception; COQ: Coquimbo; DM: Del Maule; DRL: Del Reloncaví; IQQ: Iquique; LBO: Liberator Bernardo O'Higgins; MC: Metropolitano Central; MGL: Magellanes; MN: Metropolitano Norte; MOC: Metropolitano Occidente; MOR: Metropolitano Oriente; MS: Metropolitane Sur; MSO: Metropolitano Sur-Oriente; ÑUB: Ñuble; OSN: Osorno; SS = HS: health service; TCH: Talcahuano; VDV: Valdivia; VMQ: Viña del Mar-Quillota; VSA: Valparaíso-San Antonio.

Table 2. Health services (HS) with the highest and lowest average DRG weight

Lower weight		Higher weight	
HS	**Total annual weight (average) [CI]**	**HS**	**Total annual weight (average) [CI]**
Araucanía Norte	14,823 (0.783) [CI 0.772-0.793]	Magallanes	12,480 (0.937) [0.920-0.955]
Valparaíso-San Antonio	36,769 (0.785) [0.777-0.792]	Talcahuano	20,723 (0.909) [0.897-0.921]
Iquique	14,549 (0.786) [0.773-0.799]	Valdivia	21,286 (0.902) [0.891-0.913]
Chiloé	8,596 (0.790) [0.774-0.805]	Concepción	34,399 (0.893) [0.883-0.903]
Arica	14,792 (0.791) [0.780-0.803]	Del Reloncaví	23,403 (0.891) [0.880-0.903]

CI: confidence interval; HS: health service.

4.76%), all of these differences being statistically significant ($p < 0.01$).

The distribution of the total diagnostic images and by technique according to age range is found in Fig. 4.

Discussion

This work is unpublished and the first to describe and quantify the use of DI in Chile during 1 year, also

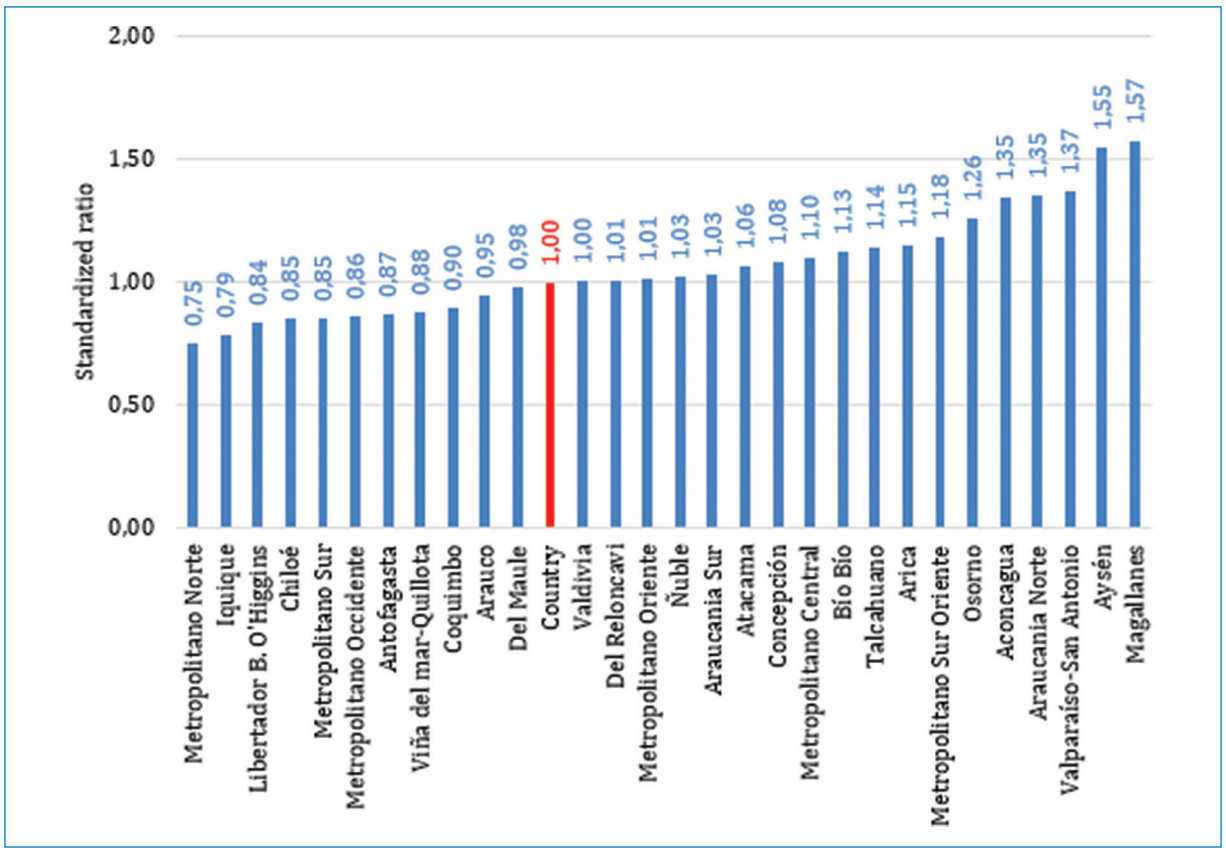

Figure 3. Standardized ratio of DRG weight by beneficiary population according to health service.

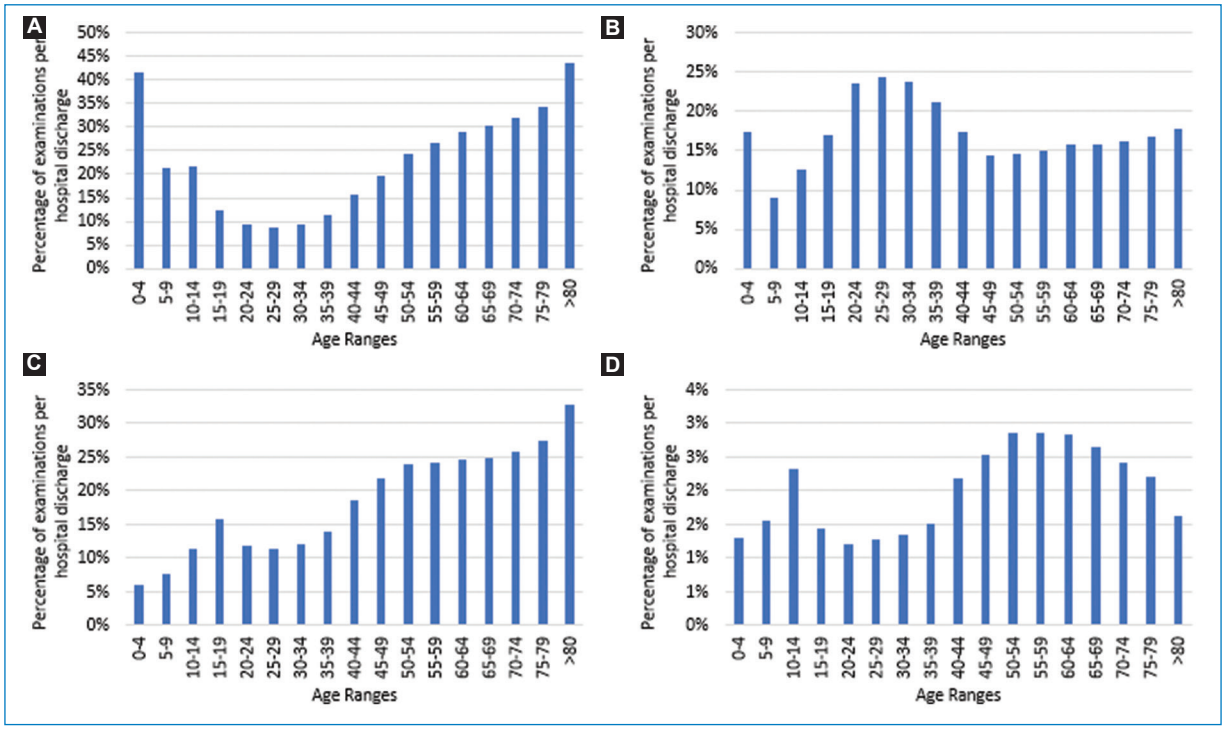

Figure 4. Percentage of examinations by age group according to technique. **A:** x-ray. **B:** ultrasound. **C:** computed tomography. **D:** MRI.

providing the most up-to-date information available at the time the research began.

Using official data from the country, we have approximated the volume of DIs performed in the hospital setting of the population that belongs to the public system (80% of the country). Currently, its comparison with other countries in the region is not possible since we did not find similar studies. It is also not possible with studies carried out in the United States of America or in Taiwan, where they have used national databases that gather records of outpatient care, emergency departments and hospitalizations[7,8,19].

With respect to the imaging technique, Chile has a different distribution in the frequency of DI by technique compared to a study in the United States of America[7]. In this case, XR was the technique most used, with 57% of DI performed, followed by US with 20%, CT with 13% and finally MRI with 6%, when comparing the proportion between DI rates by technique with respect to total of Medicare beneficiaries performed both in outpatient and inpatient care during 2016. These figures differ from our observation, where CT and US were proportionally more important (26% and 35%, respectively) at the expense of a lower percentage of X-ray and MRI. On the other hand, this study demonstrated an increase in the proportion of MRIs performed between 2003 and 2016, from 4% to 6%, a trend that could be replicated in Chile. It should be noted, as we mentioned above, that the study methods are different, since we only have data from hospitalized patients. However, it is possible to make the comparison with the outpatient setting and estimate the total DI in all clinical contexts if we use proxy values described in the literature. A similar study conducted in Taiwan in 2022 describes DI rates per 1000 visits depending on study technique and clinical setting (outpatient, emergency department, and inpatient). In it, 28, 11 and 8 times more examinations were performed in hospitalized patients than in outpatients for X-ray, CT and MRI, respectively[11]. Among the types of examinations most performed by technique, a large proportion of US in cardiology and obstetrics stands out; however, the majority of them (53%) associated with imaging departments.

We have demonstrated important differences in the distribution of total examination rates and by technique according to the different HS. It is noteworthy that the HS of Magallanes and Aysén have the highest standardized rates of total examinations and by technique (except in MRI for Aysén), and were also the ones that obtained the highest standardized DRG weight ratio. The analysis and explanation of this phenomenon is beyond our objectives, but it is an interesting aspect to elucidate in future research.

It is expected that more complex hospitalizations will consume a greater amount of resources and, therefore, have a higher DRG weight value due to the way the algorithm is constructed. In this work we have objectified that assumption showing a significant association between the use of DI and longer hospitalization time, DRG weight and case mortality. This relationship is surely supported more by the fact that patients who require DI during their hospitalization are more complex and have a higher probability of death than in a direct association. In contrast, a study demonstrated shorter hospital stays and lower mortality in hospitals that have acquired CT and MRI equipment[20].

Currently, the use of the DRG tool for coding and adequate distribution of resources is widespread in several countries and has been an element of research[21,22]. Fewer days of average hospital stay have been demonstrated when comparing DRG-funded hospitals with others funded by a cost-for-service system. In Chile there are still few works on DRG or that use it as a variable; for example, to characterize maternity discharges classified in the same way, but with important differences in resource consumption and hospital stay times[14]. Likewise, our work provides relevant and novel information with which we intend to disseminate and provide the first foundations for future studies on the impact and evaluation of the use of DI in Chile.

Conclusions

The description and characterization of the use of DI in Chile allows us to study its relationship with the complexity of hospital discharges in the public system. There are important geographical differences, with Aysén and Magallanes standing out as the HS with the highest overall DI rate. The data provided allows a good approximation of the load and performance of imaging services in public hospitals in Chile.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical disclosures

Protection of people and animals. The authors declare that no experiments have been carried out on humans or animals for this research.

Data confidentiality. The authors declare that no patient data appears in this article. Furthermore, the authors have recognized and followed the recommendations according to the SAGER guidelines depending on the type and nature of the study.

Right to privacy and informed consent. The authors declare that no patient data appears in this article.

Use of artificial intelligence to generate texts. The authors declare that they have not used any type of generative artificial intelligence in the writing of this manuscript or for the creation of figures, graphs, tables or their corresponding captions or legends.

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