

Original Article

Acute kidney injury in Latin America: a view on renal replacement therapy resources

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ABSTRACT

Background. Acute kidney injury (AKI) has increasingly been recognized as an important public health issue due to its rising frequency, its associations with early and late adverse outcomes and its economic burden.

Methods. Given the importance of determining the available resources to address this serious issue, the AKI Committee of SLANH conducted a survey to obtain information about infrastructure, human resources and equipment devoted to the treatment of AKI in Latin America

Results. A total of 246 units from 14 countries participated in the survey, the majority of them pertaining to nephrology divisions in teaching hospitals. Intermittent hemodialysis was universally performed by all of the units, and less frequently, slow extended dialysis (40%) and continuous renal replacement therapy (23%) were performed. Seventy-nine units (30%) perform peritoneal dialysis, but only 51 (19%) of them reported having treated at least 1 patient with this technique in the last 3 months pre-survey. The vast majority of the units reported adequate water treatment and use of modern filter membranes. Most of the patients received renal replacement therapy (RRT) in the intensive care unit. Specific causes of AKI were reported in different frequencies, with a heterogeneous pattern among the countries. Septic abortion, hemolytic-uremic syndrome, community-acquired diarrhea and leptospirosis were the etiologies most frequently associated with AKI.

Conclusions. To our knowledge, this report was the first available study of the equipment and human resources utilized for RRT in AKI patients in Latin America.

Keywords: acute kidney injury, developing world, epidemiology, Latin America, renal replacement

INTRODUCTION

Acute kidney injury (AKI) is a frequent and serious clinical condition caused by multiple and varied etiologies, and it is associated with poor outcomes, including a high mortality rate. It can develop both in the community (22 up to 408.5 p.m.p./year) and in hospital settings [5% of hospitalizations and up to 20% in the intensive care unit (ICU)], with highly variable incidences according different regions of the world [1]. Recent epidemiological and observational studies have underscored the association of an episode of AKI with long-term adverse outcomes, such as chronic kidney disease, end-stage renal disease, cardiovascular events and premature death [2–4]. It remains to be proven whether this relationship is causal or only a consequence of underlying risk factors [5]. In any case, this association indicates the relevance of AKI, not only as an acute syndrome potentially linked to serious long-term complications and even death but also as a mediator or marker of long-term adverse outcomes.

The actual incidence of AKI is very difficult to establish due to the lack of a uniform definition, the variability of settings in which it occurs (community, hospital and ICU) and the diverse characteristics of the affected patients (age, geographic, social and economic conditions) [6, 7]. A recent meta-analysis of worldwide AKI incidence found high heterogeneity in the published studies, with a higher representation of hospital-

acquired versus community-acquired AKI, as well as an imbalance between the northern and southern hemisphere and between high- and low-income countries [8].

Unfortunately, there is little available information regarding the characteristics and incidence of AKI in Latin America [8]. It has been postulated that in Latin American countries and in other developing countries, AKI has a bimodal pattern. In the developed urban areas of these countries, AKI characteristics are similar to those found in high-income countries: it is a predominantly hospital-acquired disease affecting mostly older, critically ill multiorgan failure patients with previous comorbidities, and it is caused predominantly by ischemia alone, frequently due to sepsis or in association with nephrotoxic drugs [9]. This profile coexists with a completely different pattern observed in remote and/or poorer areas. In these locations, AKI affects mainly young and previously healthy individuals, with a profile strongly influenced by environmental conditions and socioeconomic and cultural status [10–14]. Infectious diseases, such as leptospirosis [15, 16], malaria, dengue, yellow fever, Hantavirus and acute community-acquired diarrhea, exposure to animal venom [17], septic abortion, and exposure to herbs and compounds used in traditional medicine are prevalent causes of AKI in Latin America, and it also commonly occurs as a consequence of earthquakes and other natural disasters.

The increasing incidence of AKI, its association with severe in-hospital and long-term complications and high mortality, increases in costs and the potentially preventable nature of AKI have made it a major public health issue. In fact, AKI is considered an important public health problem today, carrying a growing clinical and economic burden. For this reason, the theme chosen for the World Kidney Day 2013 celebration was AKI, as a common, harmful, preventable and treatable kidney disease [18]. According to large epidemiological studies [19], the incidence of AKI has been estimated at between 322 and 522 cases per 100 000 population. These figures predict the occurrence of ~1 800 000–2 900 000 new cases of AKI annually in Latin America, carrying a mortality rate of between 20 and 60%, which is substantially higher than the number that die from car accidents (19.7/100 000

population) and is similar to the number that die from communicable diseases (55.5/100 000 population), ischemic heart disease (57.3/100 000 population), diabetes (36.0/100 000 population) and cerebrovascular disease (42.8/100 000 population) in Latin America [20].

Currently, renal replacement therapy (RRT) is a key component of AKI treatment. Knowledge of the available resources to address this serious health problem is extremely important. For this reason, the Acute Kidney Injury Committee of the Latin American Society of Nephrology and Hypertension (SLANH) conducted a survey aiming to obtain information about infrastructure, human resources and equipment devoted to RRT treatment of AKI in Latin American countries.

METHODS

The Latin American AKI Commission invited all of the RRT units in Latin America that treat AKI patients to participate in the SLANH survey. The Steering Committee approved the survey and sent invitations to all 22 of the national societies of nephrology that are members of SLANH. In addition, nephrologists and intensivists recognized for their interest in the subject were personally contacted and invited. A unit-based survey form, with 19 questions aimed at ascertaining the characteristics of the unit (location and size), human resources (number of nephrologists and nurses), equipment (number and type of machines, filter membranes and water treatment system), types of procedures (intermittent hemodialysis, sustained low-efficiency dialysis, continuous renal replacement therapy and peritoneal dialysis), patients (number and health coverage) and causes of AKI, was chosen (Appendix 1). The survey was conducted online using the *SurveyMonkey*® tool. The survey form was available online for 6 months.

RESULTS

Two hundred and forty-six units from 14 countries participated in the survey. Among these units, 220 (89%) were from

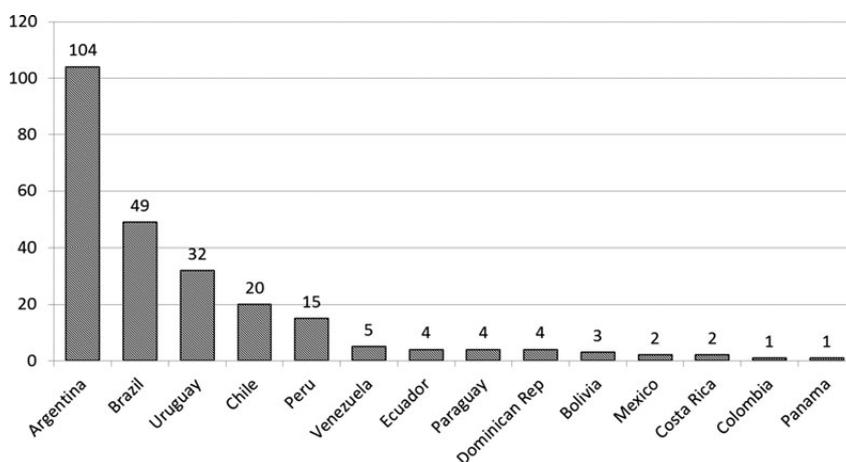


FIGURE 1: Distribution of renal replacement therapy units treating AKI that answered the survey by country.

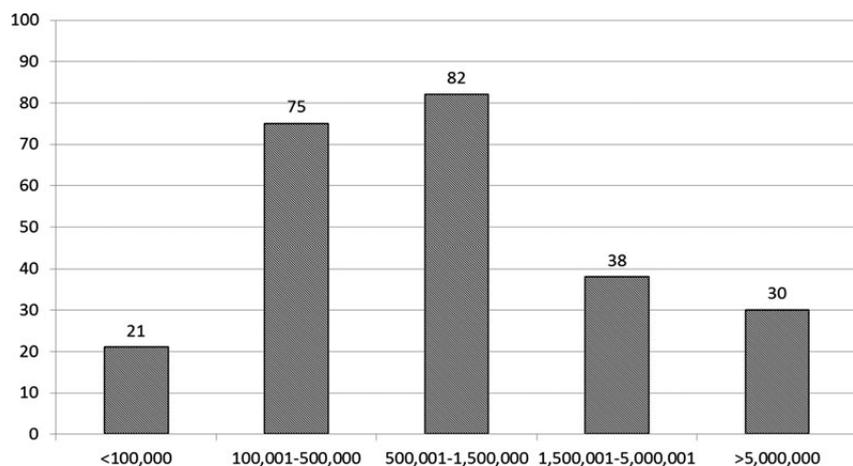


FIGURE 2: Distribution of renal replacement therapy units treating AKI that answered the survey according to the city size (in number of inhabitants).

Table 1. Renal replacement therapy units treating AKI that answered the survey distributed by hospital type and hospital location (in number of units)

	Private hospitals, 101 (41)	Public hospitals, 53 (21.6)	University hospitals, 92 (37.4)	Total, 246
Department of nephrology	41	26	54	121 (49.2)
Chronic dialysis unit	32	13	20	65 (26.4)
ICU	23	11	14	48 (19.5)
Independent	5	3	4	12 (4.9)

Values indicate absolute number and the values within parentheses indicate percentage of units.

Table 2. Number of AKI patients treated per renal replacement therapy units that answered the survey in the last 3 months according to the type of hospital

Number of patients	Private hospitals, 101 (41)	Public hospitals, 53 (21.6)	University hospital, 92 (37.4)	Total of units, 246
1–5	42 (17.1)	25 (10.2)	15 (6.1)	82 (33.2)
6–10	14 (5.7)	13 (5.3)	10 (4.1)	37 (15.1)
>10	40 (16.3)	14 (5.7)	67 (27.1)	121 (49.3)
None	5 (2.0)	1 (0.4)	0	6 (2.4)

Values indicate absolute number and the values within parentheses indicate percentage of units.

the following five countries: Argentina, Brazil, Uruguay, Chile and Peru (Figure 1).

The distribution of the units according to the sizes of the cities is depicted in Figure 2. Sixty-eight units were located in cities with >1 500 000 people, and 30 of these 68 units were located in megalopolis cities (>5 000 000 people). Most of the units were parts of the nephrology division located in private and academic hospitals, as shown in Table 1. The number of patients (ranges) treated per unit over the last 3 months, according to the type of hospital, is shown in Table 2.

The majority of the units reported that the number of nephrologists and nursing staff devoted to AKI patients were five

Table 3. Number of nephrologist per renal replacement therapy units treating AKI that answered the survey and type of hospital

Number of nephrologist per unit	Private hospitals, 101 (41)	Public hospitals, 53 (21.6)	University hospitals, 92 (37.4)	Total of units, 246
≤5	82 (33.3)	41 (16.7)	63 (25.6)	186 (75.6)
6–10	16 (6.5)	11 (4.5)	26 (10.6)	53 (21.6)
11–15	3 (1.2)	1 (0.4)	3 (1.2)	7 (2.8)

Values indicate absolute number and the values within parentheses indicate percentage over total units.

Table 4. Number of nurses per renal replacement therapy units treating AKI that answered the survey and type of hospital

Number of nurses per unit	Private hospitals, 101 (41)	Public hospitals, 53 (21.6)	University hospitals, 92 (37.4)	Total of units, 246
≤5	76 (31.0)	31 (12.6)	48 (19.5)	155 (63.0)
6–10	21 (8.1)	16 (6.5)	36 (14.6)	73 (29.7)
11–15	4 (1.6)	6 (2.4)	8 (3.2)	18 (7.2)

Values indicate absolute number and the values within parentheses indicate percentage over total units.

or less (Tables 3 and 4). In 48 of 67 units in private hospitals, the number of nephrologists was five or fewer. In addition, 29 of 92 facilities from university teaching hospitals had nephrology teams of more than six individuals.

Regarding equipment devoted to AKI, most of the units (185) had five or fewer RRT machines. Twenty-two units had 6–10 machines, and 10 units had >10 machines, all of them located in teaching hospitals. Notably, 29 units had no equipment devoted exclusively to AKI patients. Eleven of the 246 units had no ultrafiltration modules, and in eight units, the dialysis buffer was acetate. All but 12 units utilized treated water for dialysis (53% used portable osmosis devices, 23% portable containers with treated water and 17% treated water supplied through pipes). With regard to dialysis membranes, 86% of the units used synthetic membranes (polysulfone and polyacrylonitrile) and 11% used cellulose membranes (cellulose acetate). The remaining units (2%) used cuprophane membranes.

Intermittent hemodialysis was the RRT technique used in all of the units. Nearly 100 units (41%) also performed extended dialysis, 74 (30%) performed peritoneal dialysis and 31 (23%) also performed continuous renal replacement therapy. However, only 51 of 74 units that used peritoneal dialysis (PD) treated patients in the previous 3 months using this procedure (Table 5). The countries that most frequently performed PD were Brazil (31 units), Chile (10 units), Peru (10 units) and Argentina (6 units). With regard to extended dialysis, it was performed mainly in Brazil (49 units), Argentina (31 units) and Uruguay (12 units). Brazil was also the country with the most units performing continuous renal replacement therapy (CRRT) (23 units), followed by Chile (12 units) and Argentina (11 units). In the Argentinian survey, the units were also asked about the feasibility of CRRT. Only 5% responded that they were able to perform this technique. The main reasons for not performing CRRT were lack of human resources (51%) and lack of funding (34%). In 131 units (53.2%), >90% of patients were admitted to ICUs. These patients were treated by CRRT in 54% of the units (31/57) and extended dialysis in 49% (49/100), whereas PD was used only in 34% of the units.

The only requested epidemiological data were related to specific causes of AKI. Explicitly, infectious diseases (diarrhea, leptospirosis, dengue, malaria and Hantavirus), septic

Table 5. Type of renal replacement therapy performed by renal replacement therapy units treating AKI that answered the survey

Patients per unit and procedure ^a	PD ^b	SLED ^c	CRRT ^d
>50	10 (4.1)	23 (9.3)	23 (9.3)
10–50	2 (0.8)	21 (8.5)	12 (4.9)
<10	39 (15.8)	53 (21.5)	23 (9.3)
None	195 (79.3)	149 (60.7)	188 (76.5)

All the units reported performing intermittent hemodialysis. Values indicate absolute number and the values within parentheses indicate percentage over total units.

^aPercentage of patients per unit treated by type of renal replacement therapy in the last 3 months.

PD, peritoneal dialysis; SLED, slow extended dialysis; CRRT, continuous renal replacement therapy.

abortion, animal venom and hemolytic-uremic syndrome were assessed over the last 3 months before the survey (the question was: *did you treat at least one patient with AKI due to some of the following conditions?*). Table 6 shows the number of cases and their distributions by country.

DISCUSSION

AKI has been increasingly recognized as an important public health issue due to its rising frequency, its association with early and late adverse outcomes and its economic burden [21, 22]. AKI epidemiology and knowledge of the resources and infrastructure available for its treatment, especially those patients intended for RRT, are essential to devising an adequate strategy for improving the care of patients with AKI. With this goal in mind, the AKI Commission of SLANH performed the present survey, which for the first time provided information on the infrastructure, human resources and equipment available for RRT in AKI patients in the region. Although 246 units from 14 countries responded to the survey, the vast majority (220 units) came from only five countries, namely Argentina, Brazil, Uruguay, Chile and Peru. This heterogeneous response was likely related to many aspects, including population size, social-economic development, health system organization and the presence of an active national nephrology society. We found that the majority of patients were treated in units that were in nephrology divisions located in teaching hospitals. Economic support was mostly provided by public health systems. Intermittent hemodialysis (IHD) was universally performed by all of the units, whereas ~40% performed slow extended dialysis (SLED) and only 23% provided CRRT. These last two techniques were mainly available in larger units. Notably, 79 units (30%) performed PD, but only 51 (19%) of them reported having performed PD over the previous 3 months (Table 5), showing that despite PD availability in one-third of the units, <20% actually performed it as an AKI treatment. There were not clear reasons that would explain why PD, an RRT technique that is easy to install, safe, relatively

Table 6. Particular causes of AKI reported by the renal replacement therapy units treating AKI that answered the survey (in number of units)

Country	Number of units	Septic abortion	HUS	Diarrhea	Leptospirosis	Animal venom	Dengue	Hantavirus	Malaria
Argentina	104	24	12	8	5	2	0	2	0
Bolivia	3	0	1	2	0	0	0	0	0
Brazil	49	5	15	5	13	6	7	1	1
Chile	20	3	4	4	2	2	0	1	0
Colombia	1	0	1	0	1	0	0	0	0
Costa Rica	2	1	11	0	1	1	0	0	0
Ecuador	4	2	1	2	0	1	0	0	0
Mexico	2	1	1	1	1	0	1	0	0
Panama	1	0	0	0	0	1	0	0	0
Paraguay	4	1	0	2	0	0	2	0	0
Peru	15	4	6	4	1	2	2	0	0
Dominican Republic	4	2	2	2	2	0	1	0	0
Uruguay	32	0	0	10	3	0	0	0	0
Venezuela	5	1	0	0	0	1	1	0	0
Total	246	44	44	40	29	16	14	4	1

Units were asked if patients with some of these conditions were treated in the last 3 months. HUS, hemolytic-uremic syndrome.

inexpensive and particularly suitable for the conditions found in Latin America, was so underutilized. The vast majority of the units reported adequate water treatment and the use of modern filter membranes. However, 6% apparently had low dialysis quality, as demonstrated by the use of untreated water, non-ultrafiltration modules and/or acetate filter membranes. As expected, most of the patients received RRT in the ICU. Specific causes of AKI were reported in different frequencies and with heterogeneous patterns among the countries. Septic abortion, hemolytic-uremic syndrome, community-acquired diarrhea and leptospirosis were the diseases among this group of etiologies most frequently associated with AKI.

There have been few comparable studies aimed at ascertaining how AKI is managed worldwide. A recent study in 167 ICUs in the UK [23] revealed that AKI was managed mostly by intensivists, and CRRT was largely preferred (93%) over IHD (4.5%) and SLED (<1%). In this study, CRRT was performed almost exclusively by intensivists, whereas IHD was performed by nephrologists. Most ICUs were able to provide RRT only to a maximum of four patients due to limitations in the number of available machines. The authors concluded that there was a broad variation in the management of AKI in the UK. A survey conducted in the USA at the 27 sites participating in the Acute Renal Failure Trial Network (ATN) study (a trial aimed to compare an intensive versus a less intensive RRT dosing strategy in critically ill patients) revealed that 98.5% of the 130 practitioners who participated in the survey used IHD, whereas 86.2% used some form of CRRT, and only 24.6% reported using SLED. Notably, 8.5% used only IHD, and 0.8% used only CRRT. The three modalities of renal support were used by 19.2% of the respondents [24]. Another survey, from 34 Australian and New Zealand ICUs participating in the Renal Replacement Therapy Trial, which was a multicenter study conducted to compare different RRT doses in critically ill patients, showed that CRRT was the initial procedure of choice [25]. In 11 units, IHD or SLED was prescribed in hemodynamically stable patients or in those approaching ICU discharge. IHD was managed by nephrologists, whereas SLED was performed by intensivists. Another survey was conducted among participants of the 3rd International Course of Critical Care Nephrology in Vicenza [26]. Five hundred and sixty delegates from five continents, strongly biased by Europe (88%), the majority of them intensivists working in university or teaching hospitals, responded to the questionnaire. CRRT was utilized by 91% of the participants, IHD by 69%, SLED by 24% and PD by 23%. The study, which also contained data on the definition of AKI, how to begin RRT, the dose for RRT and its complications, represented the practice and personal opinion of a self-selected population strongly biased by Europeans, as stated by the authors, calling into question the representativeness of the survey.

The present survey had some limitations. The occurrence of selection bias was plausible because the practitioners contacted were mostly nephrologists, and the units prone to responding were most likely those with nephrologists interested in the field and/or inclined to participate in studies of this sort. The high frequency of units located in large teaching hospitals situated in large and modern cities supported this conclusion. This bias might have caused under-representation of less

severe cases of AKI observed in smaller units in countryside towns. Finally, the epidemiological data of AKI reflected exclusively the number of patients treated in the last 3 months prior to the survey, rather than the epidemiology pattern of AKI in the aforementioned Latin American countries. The study also had some strengths. As previously stated, it offers the first information available about equipment and human resources used for RRT in AKI patients in Latin America. In fact, the survey identified problems and deficiencies that might allow for the implementation of corrective actions, especially with regard to the technology used for RRT in AKI. The relatively large numbers of units performing PD, which were concentrated in a few countries, provided important information on the conditions for conducting multicenter studies of PD, which is a relevant tool for the treatment of AKI in low-income countries [27–30]. Finally, a network of nephrologists and intensivists was established, which could allow for the undertaking of future studies and strategies in this region.

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AUTHORS' CONTRIBUTIONS

R.L., G.R.D., A.F. and G.G. designed and conducted the study; R.L., A.F., G.R.D. and G.G. involved in data collection; R.L., G.R.D., A.F., E.A.B., G.G., L.Y. and M.Y.-I. contributed to analysis and interpretation of the data; R.L. and E.A.B. drafted the manuscript; All of the authors participated in discussions, reviewed and edited the paper and saw and approved the final draft.

CONFLICT OF INTEREST STATEMENT

None declared.

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APPENDIX 1

FORM FOR THE SURVEY OF LATIN AMERICAN UNITS REGARDING THE TREATMENT OF ACUTE KIDNEY INJURY

- (i) Country where the unit is located (open list)
- (ii) City where your unit is located (open text)
- (iii) Number of inhabitants of the city (open list)
 - (a) <100 000
 - (b) 100 000–500 000
 - (c) 500 000–1 500 000
 - (d) 1 500 000–5 000 000
 - (e) >5 000 000
- (iv) Type of unit (open list):
 - (a) Integrated into Department of Nephrology
 - (b) Integrated into a chronic dialysis unit
 - (c) Integrated into ICU
 - (d) Autonomous
- (v) Type of hospital where the unit is located (open list):
 - (a) University (public or private)
 - (b) Public non-university
 - (c) Private non-university
- (vi) Health system financing of patients assisted in your unit:
 - (a) Public (government)
 - (b) Social insurance
 - (c) Private insurance or similar
 - (d) Mixed
- (vii) Number of nephrologists devoted to the treatment of AKI patients (open list)
- (viii) Number of nurses/technicians devoted to the treatment of AKI patients (open list)
- (ix) Check the RRT performed in your unit (check all that apply) (open list)
 - (a) Conventional IHD (<4 h)
 - (b) SLED (> 6 h)
 - (c) CRRT
 - (d) PD
- (x) Number of machines dedicated to the treatment of patients with AKI (open list that also includes the following option: *We do not have exclusive machines for AKI*)
- (xi) Type of machines used for the treatment of acute patients (open list: with and without controlled UF; acetate or bicarbonate module)
- (xii) Type of dialysis membranes used in your unit (check all that apply) (open list)

- (xiii) Type of treatment water used for dialysis (open list)
 - (a) Osmosis-treated water transported in drums
 - (b) Osmosis-treated water conveyed by pipes from the central system of a chronic dialysis unit
 - (c) Portable osmosis equipment
 - (d) Non-treated water
 - (e) Other (specify)
- (xiv) Indicate how many patients with AKI were treated in your unit over the last 3 months (open list with ranks for numbers of patients)
- (xv) Indicate the proportion of these patients admitted to the ICU
- (xvi) Indicate the proportion of patients treated over the last 3 months with peritoneal dialysis (open list)
- (xvii) Indicate the proportion of patients treated over the last 3 months with SLED (open list)
- (xviii) Indicate the proportion of patients treated over the last 3 months with CRRT (open list)
- (xix) Check if during the last 3 months at least one patient with AKI due to the following disease was treated in your unit (open list):
 - (a) leptospirosis
 - (b) malaria
 - (c) hantavirus
 - (d) dengue
 - (e) venom animal bite
 - (f) septic abortion
 - (g) community-acquired diarrhea
 - (h) hemolytic-uremic syndrome

APPENDIX 2

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Due to the policy of the Argentine Society of Nephrology, the questionnaires from units in this country did not include the names of the hospitals. Participating units were located in the following provinces: Buenos Aires (38), Catamarca (1), Chaco (3), Chubut (1), Córdoba (9), Corrientes (5), Entre Ríos (2), Formosa (1), La Rioja (3), Mendoza (2), Misiones (1), Neuquén (6), Río Negro (7), Salta (3), San Juan (5), San Luis (1), Santa Fé (8), Santiago del Estero (2), Tierra del Fuego (1) and Tucumán (2).

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