Estimating Need, Demand and Supply in Primary Health Care Services: A Local Application in Argentina

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ABSTRACT

INTRODUCTION To provide equal access, health care provision should be distributed across geodemographic space based on need. In Argentina, the social security, publicly funded health care and private health care subsectors are responsible for delivering health services. In the public subsector, which is responsible for providing primary and secondary care mainly to the uninsured population, supply of services is not always associated with need. The lack of coordination between levels and subsectors makes it difficult to transform need into demand.

OBJECTIVE Design a methodology to systematically estimate need, demand and supply of primary health care services based on secondary data sources in order to assess potential mismatches in any geographical area.

METHODS An ecological analysis was conducted based on outpatient visits in primary care in Bahía Blanca, Buenos Aires Province, Argentina. A mathematical approach was proposed to systematize data collection by census tract regarding estimated need (number of outpatient visits needed, by specialty, according to age- and sex-specific care protocols and the area's demographics), demand (actual outpatient visits by specialty in each primary health care center), and supply (visit capacity or available appointment slots, taking into account number of personnel hours worked, by specialty).

RESULTS Demand for outpatient visits exceeded need (299,731) by 24% while available visit capacity (993,903) could have covered more than twice the number demanded (370,881). Analysis of the three variables grouped by area found that supply correlated more closely with demand ($\rho = 0.90$) than with need ($\rho = 0.68$), while spatial analysis showed that supply distribution responded to need. Areas with greater need had a health facility relatively close by, although supply was often located in areas of lower need, and some areas struggle with relatively high need and insufficient supply.

CONCLUSIONS Results suggest the need for some reconfiguration of primary health care in the study area. The proposed mechanism for estimating relationship among supply, demand and need is a useful tool to support decision-making.

KEYWORDS Health services needs and demand; access to health care; health care accessibility; health care quality, access, and evaluation; health care inequalities; primary health care; Argentina

INTRODUCTION

Primary health care resources should be distributed differentially to ensure equitable population access according to need. To do so requires taking into account many differences (demographic, epidemiological, geographic, sociocultural, economic and political) between groups[1] using information from population censuses, vital statistics, epidemiological studies, studies of individual perceptions, clinical measurements, as well as facility and specialty utilization rates and costs.[2]

Indicators of need must be considered separately from utilization/demand indicators, because not all needs are perceived, and when they are perceived, may not lead to attention at health services because of barriers to access (lack of money, distance, cultural differences between providers and consumers, etc.).[3] Thus, when evaluating access to health care, the dimension of need must be considered along with interactions between supply and demand. An integrated analysis can help identify whether supply adjusts to need and demand, whether need translates into demand, and whether supply falls short of demand.[4]

Methodologies available for these studies include those based on health economics, health planning, and operations research. The first type applies econometric models to study utilization based on observational data. The second applies needs indicators and assesses relative need per capita for services at various government levels by type of service. The third examines optimal use of resources by applying tools such as mathematical programming, simulation and systems dynamics, and, unlike economic or planning methodologies, involves decision-makers.[5]

IMPORTANCE The proposed methodology supports systematic estimation of a population's health service need, demand and supply in a relatively simple and low-cost way.

This last methodology's main strength is that it provides input for designing decision-making support tools based on simultaneous analysis of information about the three dimensions of interest (need, demand and supply), information which can be obtained free of cost from available secondary sources. This approach turns out to be highly useful for decision-makers in the health sector who want to optimize resource allocation.

For example, this approach has been used to determine optimal locations for community health care facilities.[6–8] It is especially important to assess where to locate primary health care (PHC) facilities, in Argentina called Primary Health Care Centers (CAPS).[9] CAPS provide less-complex services in public health systems intending to strengthen primary health care.[10] In Argentina, the health system's subsectors (public, private, and social security) are poorly integrated, leading to many situations of unequal access.[11] Some 38% of the population is uninsured and this group mostly uses the free services provided by the public subsector.[12]

Selection of CAPS locations responds to multiple factors (historic, cultural, economic, political) that can skew supply away from need. This mismatch can be observed in Buenos Aires Province where PHC provision has been delegated to local governments,

which has led to extremely unequal access to health services among regions; access ends up responding to differences in economic standard of living rather than differences in need.[13] Nevertheless, available evidence does not suggest such inequitable access within each locality.

Most studies on access to PHC services examine supply and demand through the ratio of providers to population, which can help identify resources available in a given area but does not reveal variation within it.[14–16]

Methodologies need to be designed that can answer these two questions: Is supply in each locality geographically distributed in such a way as to meet demand? To what extent does demand in each area reflect real need? Such analysis calls for information that is difficult to collect, especially in poorly coordinated decentralized health systems or those with substandard information systems. A mechanism needs to be designed to systematically estimate these figures in order to implement decision-making support tools.

Health systems that lack information systems need a protocol for deriving indicators of supply, demand and need that would enable progress toward implementation of systematic decision-making processes based on knowledge of these variables.

In the Bahía Blanca *Partido* (a subdivision of Buenos Aires Province), public health system managers have expressed concerns about matching PHC supply to need.[17] The Bahía Blanca case study is interesting for several reasons:

1. While each CAPS can treat on average about 5500 residents (1500 uninsured)—in line with widely accepted potential access conditions in relation to the estimated national average (1 CAPS for every 3184 uninsured individuals)[18]—it remains unclear whether geographic service distribution responds to regional variation in need.
2. In many cases, CAPS operate out of neighborhood development associations (nonprofit organizations that carry out activities to provide community services in the neighborhood and its surroundings). These associations opened their premises to house the CAPS and are opposed to any relocation.
3. The partido's complex situation—with a large population widely dispersed over extensive territory, and many differences evident among census tracts (socioeconomic conditions, demographic features, health and epidemiological risks, etc.)—calls for a mathematical approach.

The purpose of this study was to design a methodology based on secondary data sources to help systematically estimate supply, demand and need in PHC services in order to assess potential mismatches within geodemographic areas. Specific objectives include: design a method to estimate need for PHC outpatient visits based on specific population features; determine demand for PHC visits; quantify supply based on available personnel; and assess the relationship between supply, demand and need for PHC visits in Bahía Blanca.

METHODS

An ecological analysis was conducted to examine supply, need and demand for outpatient visits in seven basic PHC services (nursing, general family medicine, pediatrics, gynecology, obstetrics, mental health and dentistry) in Bahía Blanca Partido in 2015.

Study area Bahía Blanca Partido in Buenos Aires Province, Argentina includes three urban areas, Cabildo, General Daniel Cerri and the city of Bahía Blanca (in the remainder of the text, if Partido is not specified, Bahía Blanca refers to the city). According to Argentina's National Statistics and Census Institute, Bahía Blanca Partido's 2010 population was 301,572, 27% without health insurance.[19]

Bahía Blanca Partido's health system has facilities in the public health subsector at three government levels: municipal, provincial and national. The provincial level is responsible for the Dr José Penna Interzonal General Acute Care Hospital, and the municipal level is responsible for Dr Leónidas Lucero Municipal Acute Care Hospital and 56 CAPS. The CAPS treat less complex health problems and carry out health promotion; they treat mostly uninsured low-income individuals. Of the 56 CAPS, 5 are health centers (HC), which offer a wide range of specialties, and 51 are health units (HU) with reduced services and operating hours. The CAPS are grouped in 11 Program Areas (AP) (based on geographic, demographic, health and technical or administrative factors), each run by a management team.

Figure 1 shows the geographic distribution of CAPS in the study area, and the APs to which they belong.

Case study conception, design and application *Conception* The analysis unit for need was the census tract, a geographically defined space that includes a given number of households. Census tracts can be urban, rural or mixed, depending on population dispersion.[20] Estimates of annual outpatient visits needed per specialty in each census tract were based on size of population requiring checkups and annual frequency recommended for the population group in accordance with clinical practice guidelines and medical protocols established in Argentina.[21–30] Given that these recommendations represent the healthy population's need for routine care, the estimate was adjusted for conditions in the home in order to capture the potentially greater need associated with social determinants of health.

The CAPS was the analysis unit for quantifying supply and demand. Supply was estimated by measuring the number of visits potentially available per specialty based on annual hours worked by each professional and number of visits per hour that can be accommodated by specialty. Demand was determined by the actual number of visits by specialty in each CAPS.

Although mismatches among need, supply and demand do not necessarily occur in geographic zones and may be due to other factors, this approach (which focuses on geographic accessibility) was used to diagnose the need to relocate CAPS. Data were presented according to AP, since each CAPS belongs to an AP, which comprises a set of census tracts. To assess the relationship among dimensions—supply, demand, and need—the Pearson correlation coefficient, ρ, was calculated for all visits by specialty for demand and supply (by CAPS and AP) and for supply and need (by AP). Correlation thresholds were $\rho = 0.9$ for very strong, $\rho = 0.75$ for strong, $\rho = 0.5$ for moderate, $\rho = 0.25$ for weak, and $\rho = 0.1$ for very weak.[31] SPSS 15 software was used. Analytical distribution maps were compiled by geographical zone (for need)

and facility (for supply and demand); form, color and size were used as visual representation. The shade of each census tract represented level of need for visits. We used SIG software[32] for classification using the natural breaks method,[33] which identifies maximum homogenization within each classification and maximum difference among classifications, so limits can be established when a relatively significant jump occurs between values.[34,35] CAPS were represented by concentric black and grey circles proportionate to size of the facility's supply of and demand for visits, respectively.

Design Need. Annual need per census tract for each specialty was estimated based on size and requirements of different population groups (PG) according to age and sex. To capture health needs, the following PGs were defined: aged<1 year, aged 1 year, aged 2 years, aged 3–4 years, aged 5–9 years, girls aged 10–14 years, boys aged 10–14 years, women aged 15–19 years, men aged 15–19 years; women aged 20–39 years, men aged 20–39 years, women aged 40–64 years, men aged 40–64 years, women aged ≥65 years, and men aged ≥65 years. Estimates of need were made with the following equation, in which each census tract's needs depend on number of individuals in the different population groups ($P_{p,r}$) and a set of variables and parameters:

$$N_{r,j}=\sum_p\{(pn_{p,j} * fn_{p,j}) * SC_p * (1 + DS_r) * P_{p,r}\} (1)$$

$N_{r,j}$ = specialty *j* visits needed in one year in census tract *r*

$P_{p,r}$ = number of individuals belonging to $\mathrm{PG}p$ in census tract *r*

SC_p = uninsured proportion of $\mathrm{PG}p$

DS_r = proportion of population exposed to adverse living conditions in census tract

$pn_{p,j}$ = proportion of $\mathrm{PG}p$ needing specialty *j*

$fn_{p,j}$ = annual frequency of visits in specialty *j* needed by $\mathrm{PG}p$

SC_p represents the proportion of uninsured individuals in a PG and is significant because this is generally the only population that demands PHC services in the publicly funded health care subsector. The parameters $pn_{p,j}$ and $fn_{p,j}$ represent proportions of the population that would use each specialty according to age and sex, respectively, and number of annual checkups recommended for each PG by specialty. These factors are fundamental inputs to obtain the number of visits needed based on each census tract's demographic data. Their values are established according to evidence-based medical guidelines for routine care in healthy populations.[21–30] To replicate the study in another area, parameters should be adapted to outpatient visits needed by specialty according to health authorities' criteria in each jurisdiction, determined by adapting sound international scientific evidence to the local context to derive minimum requirements.

Finally, assuming that adverse socioeconomic conditions can swell the need for health services beyond scientifically based recommended levels for healthy populations, the number of outpatient visits needed in each census tract was affected by parameter DS_r, which measures general environmental quality of life. Each census tract's housing shortage was estimated by the proportion of critically overcrowded households (indicated by the variable *overcrowding* recorded in the national census: households with >3 individuals per room). Household overcrowding was included as a surrogate for the social determinants of health.[36]

Demand. Annual demand by specialty ($D_{c,j}$) was obtained for each CAPS from number of visits registered by the health authority ($R_{c,j}$). Since these figures can vary, the following calculation is proposed:

$$D_{c,j} = \epsilon_{c,j} * R_{c,j} (2)$$

in which:

$D_{c,j}$ = specialty *j* visits demanded in one year in CAPS c

$R_{c,j}$ = specialty *j* visits registered in one year in CAPS c

$\epsilon_{c,j}$ = correction factor for specialty *j* demand in CAPS c

$0 \leq \epsilon_{c,j} \leq 1$

With the addition of factor $\epsilon_{c,j}$, the formula is adjusted for potential over-registration, capturing situations in which the target population's demand for outpatient visits does not match the number of visits registered by the health authority. Such differences can occur when individuals with health coverage or residents of other municipalities use PHC services in the study area. This factor can vary from one CAPS to another. For example, facilities with greater response capacity and facilities located near the partido's borders are more likely to attract individuals who are insured or who live in neighboring areas. This factor could also vary by service. It is difficult to obtain in poorly computerized systems and can be estimated based on surveys of CAPS personnel and client population or obtained from health authority registries.

Supply. Annual supply in each CAPS by specialty ($O_{c,j}$) was calculated based on time available per year and each specialist's productivity:

$$O_{c,j} = \beta_j * (Hs_{c,j} * Sa) (3)$$

in which:

$O_{c,j}$ = specialty *j* visits provided in one year in CAPS *c*

β_j = specialty *j* visits provided per week

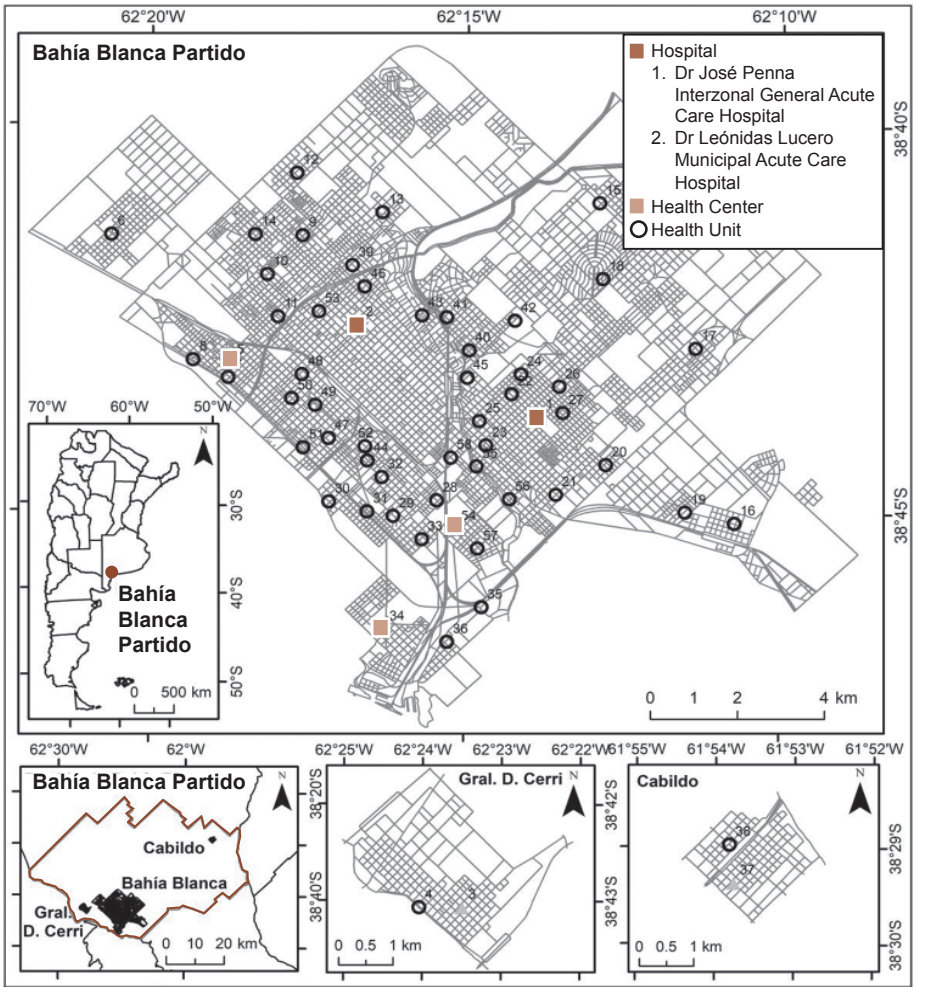
$Hs_{c,j}$ = specialty *j* hours available per week in CAPS *c*

Sa = number of weeks per year

To determine the supply (visit capacity), the annual number of available hours was multiplied by a parameter measuring the specialty's productivity (β_j) approximated by maximum possible number of visits per hour. According to a literature review, the average time for a clinical outpatient visit is 10–15 minutes,[37] which would give β_j values of 4–6. This figure may differ from one CAPS to another.

Hours per week by specialty in each CAPS ($Hs_{c,j}$) were obtained by multiplying total number of health personnel (nurses, physicians,

Figure 1:Study area and PHC facility locations, Bahía Blanca Partido, Argentina (2015)



Program Area 1	Program Area 5	Program Area 9
3 A. Menghini Health Center	22 Anchorena Health Unit	39 San Cayetano Health Unit
4 Cem Health Unit	23 Barrio Obrero Health Unit	40 Bella Vista Health Unit
Program Area 2	24 Sanchez Elias Health Unit	41 La Falda Health Unit
5 L. Piñeiro Health Center	25 Villa Mitre Health Unit	42 Miramar Health Unit
6 Villa Bordeau Health Unit	26 Villa Amaducci Health Unit	43 Naposta Health Unit
7 Villa Nocito Health Unit (Ext)	27 Don Bosco Health Unit	44 Pedro Pico Health Unit
8 Maldonado Health Unit (Ext)	**Program Area 6**	45 Tiro Federal Health Unit
Program Area 3	28 Centenario Health Unit	46 Universitario Health Unit
9 Avellaneda Health Unit	29 Enrique Julio Health Unit	**Program Area 10**
10 Estomba Health Unit	30 L. Paraguaya Health Unit	47 Colon Health Unit
11 Lujan Health Unit	31 Villa Delfina Health Unit	48 Mariano Moreno Health Unit
12 N. Belgrano Health Unit	32 Villa Ressia Health Unit	49 Noroeste Health Unit
13 Villa Floresta Health Unit	33 Villa Rosas Health Unit	50 Pampa Central Health Unit
14 Barrio Latino Health Unit	**Program Area 7**	51 San Dionisio Health Unit (Ext)
Program Area 4	34 Menor I. White Hospital	52 San Martin Health Unit
15 Aldea Romana Health Unit	35 Saladero Health Unit	53 Kilometer 5 Health Unit
16 Grünbein Health Unit	36 San José Obrero Health Unit	**Program Area 11**
17 Villa H. Green Health Unit	**Program Area 8**	54 Spurr Community Integration Center
18 Patagonia Health Unit	37 Cabildo Health Center	55 Rosario Sur Health Unit
19 Villa Gloria Health Unit	38 S. Claire Health Unit (Ext.)	56 Villa Esperanza Health Unit
20 12 de Octubre Health Unit		57 Villa Serra Health Unit
21 Villa Muñiz Health Unit		58 Rivadavia Health Unit

Ext: extension of a larger health center or unit
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technicians, etc.) assigned to CAPS *c* ($RH_{c,j}$) by hours contracted per week (C_j):

$$Hs_{c,j} = \alpha_{c,j} * C_j * RH_{c,j} (4)$$

$RH_{c,j}$ = specialty *j* professionals in CAPS *c*

C_j = weekly hours contracted by specialty *j* professionals

$\alpha_{c,j}$ = correction factor for specialty *j* supply

$0 \leq \alpha_{c,j} \leq 1$

The value C_j assumes a homogeneous format for contracts in which all professionals in a certain specialty are contracted for the same number of hours per week in the CAPS where they work. A more general model could consider the weekly number of hours contracted, which differs from one CAPS to another or even among individual professionals.

Parameter $\alpha_{c,j}$ was also incorporated as a correction factor for outpatient visit capacity per year to consider the amount of time specialists allot to work activities not directly involved in patient care (teaching, research and/or administration) and to more precisely estimate the amount of time effectively available for patient visits. The parameter may vary according to specialty and to CAPS. Its estimated values should be determined based on interviews with health personnel.

Application in Bahía Blanca Partido Need estimates were made based on population data from the 369 census tracts of the 2010 national census (excluding nine rural census tracts with a total population of 7340).[19] Populations per PG in 2015 were estimated based on 2010 population per census tract adjusted by the average municipal annual population growth rate according to projections for 2015[38] and proportions represented by each PG in 2010. Health coverage for each PG was estimated from municipal and provincial data.[39,40] With respect to nursing services, the maternal and child population was not affected by the correction factor, since it is mandatory for all pregnant women, as well as new mothers and children, to receive services at a CAPS facility for vaccinations (in accordance with the country's official immunization schedule). Table 1 presents proportions of each PG in total population and percentages of uninsured.

Supply was estimated based on number of professionals assigned to each CAPS, ac-

Table 1: Health coverage by population group, Bahía Blanca Partido, 2010

Age (years)	Sex	Proportion of total municipal population	Percentage uninsured or using public health services (%)
<1	both	0.01	33
1	both	0.01	33
2	both	0.01	33
3–4	both	0.02	33
5–9	both	0.07	31
10–14	M	0.03	32
	F	0.03	33
15–19	M	0.04	35
	F	0.03	34
20–39	M	0.15	30
	F	0.15	31
40–64	M	0.12	27
	F	0.14	23
≥65	M	0.05	5
	F	0.07	3

Source: 2010 National Population and Household Census, Argentina

cording to whether they have 24- or 40-hourweek contracts with an average visit session lasting 16.7 to 18.5 minutes,[41] an adjusted figure based on expert opinions in the specialty. Finally, due to lack of information on supply and demand correction factors, these were considered to be equal to 1. Data were provided by the Health Secretariat of Bahía Blanca Partido.

Need for outpatient visits by specialty was estimated based on the values of $pn_{g,j}$ and $fn_{g,j}$ as determined from a literature review (clinical practice guidelines, population studies, utilization rates, etc.). In Table 2, each specialty has two columns: indication for visit and frequency of visit.

All children aged <1 year, for example, should be brought to CAPS for 12 visits with a nurse and 10 pediatric checkups annually. This group does not require treatment from other specialties at PHC levels.

Nursing services included vaccinations according to Argentina's national schedule.[21] For children and adolescents, information from pediatric and dental services was used as recommended by the Argentinean Pediatrics Society;[22] and for adults, from the regularly scheduled routine medical care of healthy adults.[23,24] For mental health, prevalence of psychiatric disorders was used, as well as proportion of the national population aged ≥15 years affected by mental and behavioral disorders.[25,26] For obstetrics, we assumed the early adolescent (ages 10–14 years) and late adolescent (ages 15–19 years) pregnancy rates for Buenos Aires Province and the mean age-specific fertility rates for women aged 20–39 years; and estimated needed visit frequency according to health authorities' recommendations for Buenos Aires Province and Argentina regarding antenatal care in low-risk pregnancies.[27–30]

RESULTS

According to 2010 projections, an estimated 299,731 outpatient visits with all PHC specialists treating Bahía Blanca's uninsured population were needed in 2015 (with the exception of nursing services, which provide treatment for the entire maternal and child population). The population in each census tract needed an average of 812 visits. The census tract with the least need registered 81 visits and the one with the most 3095.

Distribution of need for outpatient visits by specialty included: nursing services (41%), dentistry (25%), pediatrics (17%), gynecology (35%), mental health (4.6%), general family medicine (3%) and obstetrics (2%). However, need for services varied by neighborhood and locality.

Table 2: PHC outpatient visits by specialty, Bahía Blanca Partido, Argentina (2015)

Population group		Nursing*		General family medicine		Gynecology		Obstetrics		Pediatrics		Mental health		Dentistry	
		Ind	Freq	Ind	Freq	Ind	Freq	Ind	Freq	Ind	Freq	Ind	Freq	Ind	Freq
Age (years)	Sex														
<1	both	1.00	12	—	—	—	—	1.00	—	1.00	10	1.00	—	1.00	—
1	both	1.00	7	—	—	—	—	1.00	—	1.00	4	1.00	—	1.00	—
2	both	0.00	—	—	—	—	—	0.00	—	1.00	2	0.00	—	1.00	1
3–4	both	0.00	—	—	—	—	—	0.00	—	1.00	1	0.00	—	1.00	1
5–9	both	0.20	3	—	—	—	—	0.00	—	1.00	1	0	—	1.00	2
10–14	M	0.19	1	—	—	—	—	—	—	1.00	1	0.2	1	1.00	1
	F	0.19	2	—	—	0.00	—	0.00	5	1.00	1	0.2	1	1.00	1
15–19	M	0.00	—	—	—	—	—	—	—	1.00	2	0.2	1	1.00	1
	F	0.06	3	—	—	1.00	0.5	0.06	5	1.00	2	0.2	1	1.00	1
20–39	M	0.00	—	1.00	0.2	—	—	—	—	—	—	0.2	1	1.00	1
	F	0.10	3	1.00	0.2	1.00	0.5	0.1	5	—	—	0.2	1	1.00	1
40–64	M	1.00	0.1	1.00	0.2	—	—	—	—	—	—	0.2	1	1.00	1
	F	1.00	0.1*	1.00	0.2	1.00	0.5	0.00	—	—	—	0.2	1	1.00	1
≥65	M	1.00	1.1	1.00	1	—	—	—	—	—	—	0.2	1	1.00	1
	F	1.00	1.1	1.00	0.5	0.00	—	0.00	—	—	—	0.2	1	1.00	1

*vaccination according to national schedule Freq: frequency (number of visits recommended annually)
Ind: indication (proportion of population in need of service; 0 = no one 1 = everyone) PHC: primary health care

Demand was quantified at 418,214 outpatient visits. There were 370,881 visits with specialists (89% of total). Differences among CAPS were significant: CAPS that provide specialties handled 36% of visits and 4 of the 5 HCs accounted for 20% of total visits. Average number of visits per CAPS was 4302 in nursing, 1111 in general family medicine, 518 in pediatrics, 251 dental appointments, 151 in mental health services, 147 in gynecology, and 116 in obstetrics (values varied among CAPS).

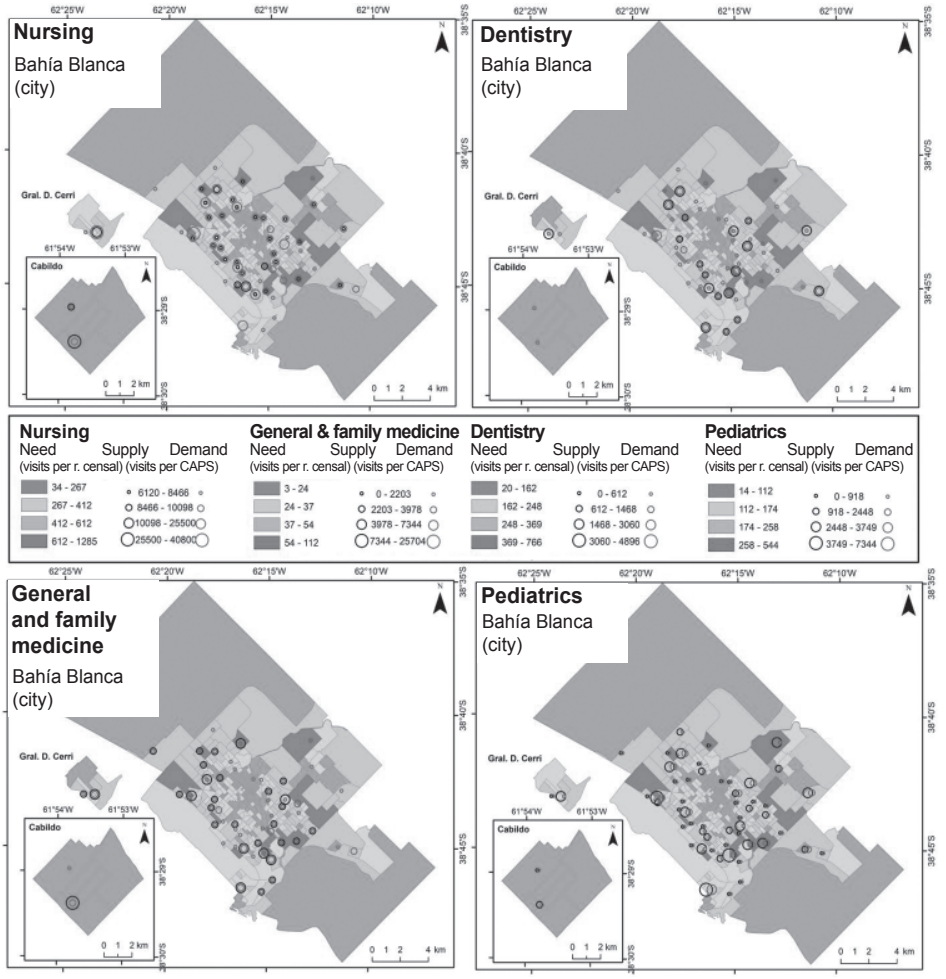
Regarding supply, available municipal PHC person-hours in 2015 were sufficient for a total of 993,903 outpatient visits. CAPS provided an average of 10,162

appointments in nursing, 3287 in general family medicine, 1508 in pediatrics, 819 in gynecology, 761 dental appointments, 624 in obstetrics and 558 in mental health services. Important differences were observed among CAPS in outpatient visits by specialty: an average of 3638 pediatric visits in each CAPS providing all specialties (4 HCs and 7 HUs), but only 1110 in CAPS with pediatric services but not all the other specialties (1 HC and 26 HUs).

Based on this protocol, it was estimated that in 2015 Bahía Blanca saw demand exceed need (299,731 visits) by about 24%, while theoretical supply (993,903 visits) was more than twice the number of visits demanded (370,881).

Distribution of need, supply and demand was mapped spatially for each service, For reasons of space, results are presented for only four services (nursing, dentistry, general family medicine, and pediatrics), selected because they revealed different types of results: nursing services accounted for greatest need (41%), supply (57%) and demand (65%); general family practice services accounted for the next greatest supply (19%) and demand (17%) but not need (4%); dentistry presented greater need among services (25%) with insufficient supply to cover it, and pediatrics presented somewhat high need (17%) totally covered by supply.

Figure 2: PHC outpatient visit need, demand, and supply by service, Bahía Blanca Partido, Argentina (2015)



CAPS: primary health care centre PHC: primary health care
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Figure 2 shows that spatial distribution of need is similar among services. The census tracts needing more annual visits coincide for all services and are generally located on the periphery of Bahía Blanca. Supply dispersion increases the further a CAPS is located from the center of the city. The CAPS with greatest supply, however, are not necessarily located in the census tracts with the greatest need.

Most census tracts with greater need had a CAPS nearby, and all five HCs were located in the areas with greatest need. On the other hand, for all services, there were CAPS in low-need census tracts. For all services there were no CAPS nearby in census tracts with mid-level needs.

Table 3 presents distribution of supply, demand, and need for outpatient visits by AP for each specialty.

Nursing services were the most readily available and provided 57.3% (569,058) of total visit supply (993,903), followed by general family practice with 18.5% (184,059) and pediatrics with 8.5% (84,441). Over half of total PHC supply was concentrated in five APs: AP #4 with population of 108,304 (10.9%), AP #9 with 107,222 (10.8%), AP#5 with 102,485 (10.3%), AP #2 with 100,929 (10.2%), and AP#10 with 98,430 (9.9%). Each of these APs contained at least one CAPS that provided all specialty services.

With respect to distribution of demand by AP and specialty, it was observed that nursing, general family medicine, and pediatric services accounted for 90% of visits and 65% (240,890), 16.8% (62,189) and 7.8% (29,038) of demand (370,881), respectively. Four APs (AP #9 with population of 56,994 or 15.4%, AP #3 with 50,035 or 13.5%, AP #4 with 42,885 or 11.6%, and AP #10 with 40,500 or 10.9%) accounted for over half of total visits. The CAPS of Cerri (AP #1); White (AP #7) and Cabildo (AP #8) accounted for smaller percentages of visits in all specialties (5.8%, 4.9%, and 2.8%, respectively).

The correlation assessment indicated a positive and strong relationship between supply and demand when analyzed by CAPS as well as by AP, except for general family medicine. In both CAPS and AP analyses, the highest correlation coefficients corresponded to pediatrics (0.929 and 0.951, respectively).

Distribution by AP of outpatient visits needed indicated that those with greater need also presented greater demand. These were: AP #9 with a need for 82,371 visits (27.5%), AP #10 with 42,024 (14%), AP #3 with 38,907 (13%) and AP #4 with 34,805 (11.6%), which together covered 66% of total need (299,727) and 52% of demand (370,881). A strong positive correlation was found be-

Table 3: PHC outpatient visit supply, demand and need by specialty and AP, Bahía Blanca Partido, 2015

Program area	Nurse			General family medicine			Gynecology			Obstetrics			Total		
	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need
β	4	—	—	3	—	—	3	—	—	3	—	—	—	—	—
1	32,640	17,025	2,795	8,262	2,933	250	3,672	287	331[a]	1,836	0	200[a]	54,366	21,685	6,760
2	65,280	24,653	5,969	12,240	4,309	529	4,590	945	709	4,820	1,560	428	100,929	36,083	14,414
3	46,920	30,449	16,083	20,426	9,313	1,439	6,197	2,773	1,907	0	10	1,151[a]	91,877	50,035	38,907
4	57,630	24,244	14,396	17,626	7,555	1,284	4,590	1,219	1,708[a]	4,590	1,159	1,031	108,304	42,885	34,805
5	66,300	24,067	12,873	17,060	4,395	1,153	3,672	752	1,526[a]	4,590	817	921[a]	102,485	33,407	31,147
6	57,120	20,107	8,937	15,422	5,674	799	3,672	892	1,060[a]	4,590	531	640[a]	94,513	29,273	21,614
7	32,640	8,138	4,303	12,852	3,548	385	3,672	112	510[a]	3,672	668	308	68,748	18,157	10,408
8	43,248	4,816	831	26,622	4,186	75	918	401	98	0	0	59	74,154	10,532	2,012
9	66,504	45,455	34,032	11,016	3,125	3,053	7,344	1,542	4,032[a]	4,590	506	2,433[a]	107,222	56,994	82,371[a]
10	57,120	26,120	17,372	21,114	10,155	1,554	2,754	552	2,059[a]	3,672	65	1,243[a]	98,430	40,500	42,024[a]
11	43,656	15,816	6,319	21,420	6,996	562	4,774	271	750[a]	3,534	1,206	453	92,876	31,330	15,268
Total	569,058	240,890	123,910	184,059	62,189	11,081	45,854	9,746	14,690[a]	35,894	6,522	8,866[a]	993,903	370,881	299,727

Program area	Pediatrics			Mental health			Dentistry			Total		
	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need
β	2	—	—	1	—	—	1	—	—	—	—	—
1	3,672	846	1,179[a]	1,224	0	314[a]	3,060[b]	594	1,691[a]	54,366	21,685	6,760
2	8,109	2,332	2,522[a]	3,341	702	666	2,550[b]	1,582	3,592[a]	100,929	36,083	14,414
3	10,175	4,217	6,784[a]	2,550	1,084	1,806[a]	5,610[b]	2,189	9,738[a]	91,877	50,035	38,907
4	14,688	5,704	6,076[a]	4,284	1,645	1,613	4,896[b]	1,359	8,698[a]	108,304	42,885	34,805
5	6,885	1,636	5,428[a]	1,938	898	1,447[a]	2,040[b]	842	7,800[a]	102,485	33,407	31,147
6	7,344	1,578	3,770[a]	1,469	134	1,003[a]	4,896[b]	357	5,407[a]	94,513	29,273	21,614
7	7,344	2,968	1,815	3,672	1,191	483	4,896[b]	1,532	2,604[a]	68,748	18,157	10,408
8	1,836	581	350	1,530	548	93	0[b]	0	504[a]	74,154	10,532	2,012
9	9,180	3,850	14,345[a]	3,692	1,158	3,829[a]	4,896[b]	1,358	20,646[a]	107,222	56,994	82,371[a]
10	4,590	1,348	7,327[a]	4,284	410	1,950[a]	4,896[b]	1,850	10,517[a]	98,430	40,500	42,024[a]
11	10,618	3,978	2,669	3,978	697	706[a]	4,896[b]	2,366	3,810[a]	92,876	31,330	15,268
Total	84,441	29,038	52,266[a]	31,962	8,467	13,909[a]	42,636[b]	14,029	75,006[a]	993,903	370,881	299,727

[a]need > demand [b]supply < demand < need AP: Program Area β: number of visits per hour
Source: Health Secretariat, Bahía Blanca Partido

tween demand and need by AP (ρ = 0.90), while the correlation between need and supply was still positive but weaker (ρ = 0.68) and varied according to specialty: considerable for nursing services (ρ = 0.754) and weaker for general family medicine (ρ = 0.252).

Comparison of 2015 visit numbers showed that, except for nursing and general family medicine services, some APs presented greater need than demand. This was observed in all APs for dentistry, the only service in which supply did not match total coverage needed overall, nor by AP (except for AP #7). For total services, AP #9 and AP #10 were the only ones where need for visits exceeded demand. In AP #10, supply exceeded need, which was not true for AP #9.

DISCUSSION

Various methodologies have been used to examine the relationship between supply, need and demand in health services. A study in Canada assessed whether distribution of PHC nurses and physicians matched population needs (measured by standardized mortality rate).[42] A study in Mexico determined that the need for PHC physicians and nurses per inhabitant (estimated based on expert opinions and utilization data) was greater than supply.[43] Murphy estimated drug shortages using a needs-based simulation model, keeping in mind age, sex, health status and service-use rates.[44] Teerawattananon looked at burden of disease associated with reproductive health as a measure of need in order to design a basic package as part of a universal coverage plan.[45] De Graaf-Ruizendaal estimated need for outpatient visits based on census and service utilization data.[46] Barber Pérez assessed need for medical specialists by region, applying international standards for ratios of human resources to population.[47]

A study in Argentina analyzed each CAPS' geographic accessibility using effective demand (measured by prescriptions filled) and potential demand (estimated by population density of each census tract in the CAPS catchment area), revealing that some areas had unmet need.[48]

Unlike these studies, we proposed to differentiate need from demand by applying mathematical models to enable estimates based on secondary data sources. Mathematical modeling for optimal positioning of health services has antecedents in the literature. In Cuba, a study of physician demand and distribution used an information tool based on the center of gravity method[49] (which minimizes travel distance) to characterize physician demand by assigned population and evaluate allocation improvements. Griffin implemented an optimal allocation model based on health conditions and utilization rates[50] to estimate visits needed in services provided by HCs. But these studies do not consider differences between need and demand,[42,51] or if they do use some concept of need, it is with broad strokes based on population statistics and some characteristics that modify need.[52]

A study in Argentina to quantify the difference between demand and need examined public provision of medications for uninsured diabetic patients. The results indicated that total public supply covers only about one quarter (25%) of treatment need.[53]

The main innovation of our contribution is including medical recommendations in estimates of need for outpatient visits and not utilization rates, in recognition that utilization indicators do not take into account potential obstacles to access. The method can potentially be extended to all specialties and/or practices where it is possible to identify recommendations by PG. The proposed methodology is also easy to implement via spreadsheets and can be replicated in other regions by updating the data sources.

However, several constraints can be identified:

1. While in the effort to prevent information bias it would be appropriate to use datasets recorded in the same year, this was not possible due to lack of annual population statistics and unavailability of information on supply and demand in 2010. The decision was thus made to use population projections for 2010 to 2015 (the year of the study), information which is available at the national level.
2. Need may be underestimated since only scheduled checkups are considered, while a significant proportion of outpatient visits in CAPS are spontaneous visits associated with common health problems requiring quick solutions. The difference between need and demand can be expressed by including a correction factor for demand based on estimates of the proportion of this type of outpatient visit.
3. Estimates of need are based on PHC clinical practice guidelines for checkups for the healthy population in the study area. Although it was proposed that visit indication and frequency for each specialty follow recommendations based on independently developed evidence, it is recognized that their applicability to other geodemographic contexts would require adapting care protocols to local features, such as, for example, the local epidemiological profile.
4. Although CAPS are expected to serve as the entry gateway to the health system, a proportion of the population seeks out a hospital for a problem that could be appropriately resolved in a PHC facility. This factor could be captured by including as units of analysis hospital ambulatory care clinics that provide these specialty services.
5. Estimates of service supply should take into account the amount of time professionals are available to see patients and the amount of time dedicated to additional activities (such as administration) in the CAPS. This factor could explain the wide mismatch observed between supply and demand.
6. Application of supply and demand correction factors that have theoretically been determined would require fieldwork that exceeds the scope of the present study. For this reason, these factors were applied with a value of 1. However, they could be estimated based on secondary data sources or information from health authorities. This article is the partial result of a larger study to develop a mathematical model for redesigning PHC.

CONCLUSIONS

The proposed methodology enables relatively simple, systematic, low-cost estimation of a population's health care needs, supply and demand. Such information is essential for making decisions about PHC design in the community and is often difficult to obtain directly in large or poorly computerized systems.

In the case of Bahía Blanca, where some areas were observed to have relatively high need yet no CAPS nearby, the findings indicated the appropriateness of redesigning supply of several PHC services to more closely match distribution to estimated need.

The tool can be replicated in any geodemographic area and applied over time as the variables that determine need, supply and demand change. It has the capacity to predict future discrepancies and can therefore be widely used in PHC services planning. A future line of investigation is to modify the methodology to calculate precise values for the proposed correction factors.

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