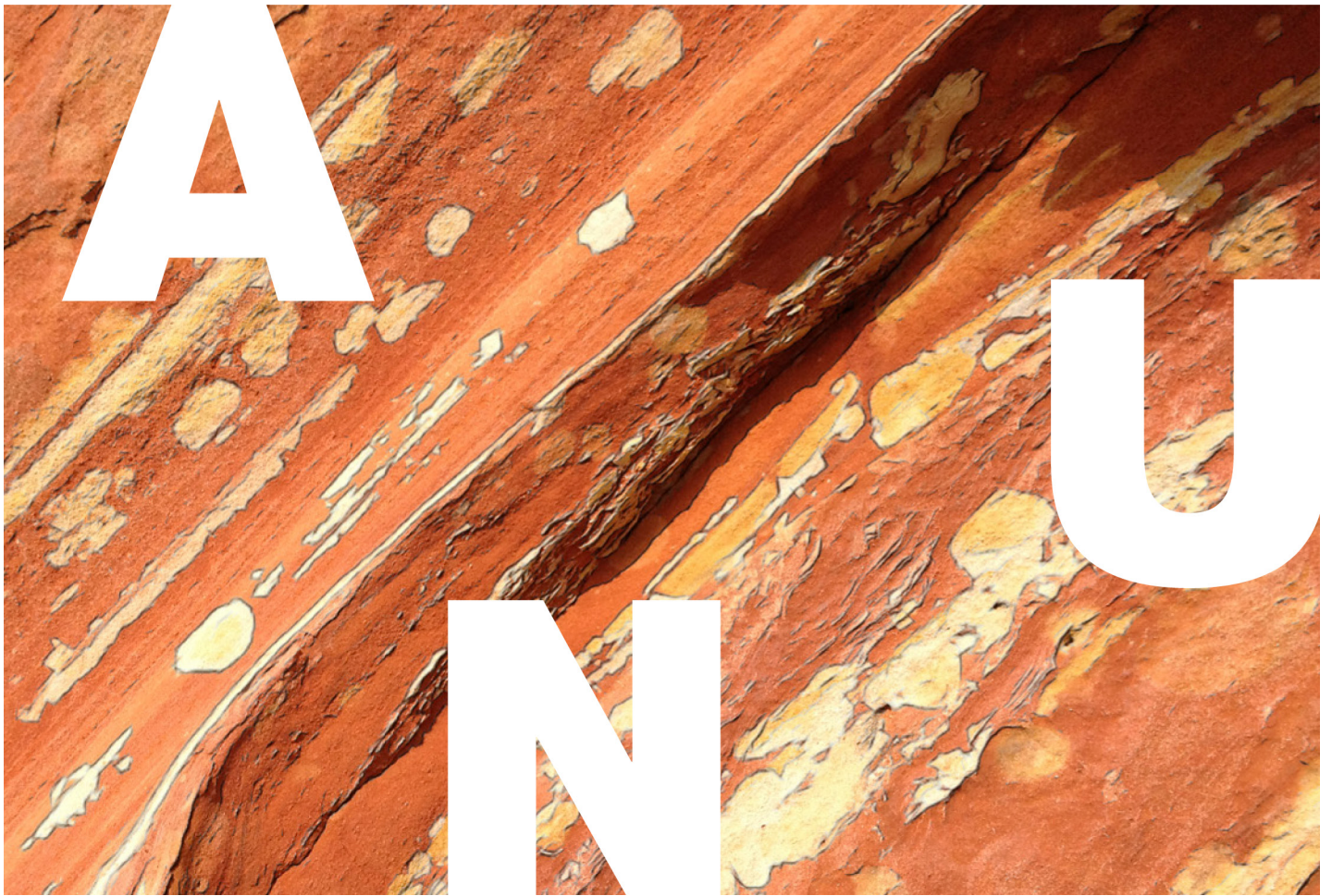




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NEW DIRECTIONS IN INDIGENOUS SERVICE POPULATION ESTIMATION

F. MARKHAM, J. BATH, J. TAYLOR
AND B. DORAN

Centre for
Aboriginal Economic
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ANU College of
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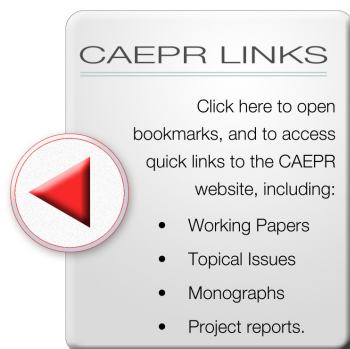
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Research School of Social Sciences
College of Arts & Social Sciences
The Australian National University
April 2013



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F. Markham, J. Bath, J. Taylor
and B. Doran

Francis Markham is a Research Officer, **John Taylor** is a Visiting Fellow, and **Bruce Doran** a Research Fellow at the Centre for Aboriginal Economic Policy Research, Research School of Social Sciences, College of Arts and Social Sciences, The Australian National University. **Jess Bath** was previously a Research Officer at CAEPR is now a doctoral scholar at Flinders University.

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Abstract

Accurate assessments of the number of people who access goods or services in a particular location are crucial to the equitable allocation of resources and the delivery of services. In particular, Indigenous Australians are an important subpopulation for whom such estimates would be useful, given the high levels of Indigenous temporary mobility. We review previous estimates of service populations relevant to Indigenous Australians and find that there is no currently accepted method for quantification. We argue that any attempt to develop a single measure of service populations for all services at a place is likely to meet only limited success. Instead, we propose that service populations should be estimated on a service-by-service basis. We then give a hypothetical example of how the Indigenous service populations of hospitals might be estimated using existing administrative data and a geographical approach. We conclude by arguing that access to key datasets remains the most important barrier to the estimation of Indigenous service populations.

Keywords: Indigenous demography, service delivery, population dynamics, Indigenous migration and mobility, Indigenous temporary mobility, Indigenous geography

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Acronyms

ABS	Australian Bureau of Statistics
AMSANT	Aboriginal Medical Services Alliance Northern Territory
ATSIC	Aboriginal and Torres Strait Islander Commission
AIHW	Australian Institute of Health and Welfare
CAEPR	Centre for Aboriginal Economy Policy Research
COAG	Council of Australian Governments
DLGPSR	Department of Local Government, Planning, Sport and Recreation
ERP	estimated resident population
LGA	local government area
STA	Survey of Tourist Accommodation

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Introduction

Service population estimates—assessments of the number of people who access goods or services in a particular location—are valuable for the effective allocation of resources and the delivery of services. As a consequence, the breadth of demand for such estimates is considerable, spanning government agencies at the Federal, State and local levels, grants commissions, businesses and individual service providers. Government agencies seek service population estimates to assist with policy and planning activities and the estimation of costs associated with service provision (Australian Bureau of Statistics (ABS) 1996). Local Government Grants Commissions seek service population estimates for use as supplements to estimated resident populations (ERPs) in funding allocation models (ABS 1996).

Accurate Indigenous service population estimates are especially important given that relatively high levels of Indigenous temporary mobility make population estimates based on census-derived measures of usual residency especially difficult to determine. Of particular interest are accurate data regarding the size, composition and spatial distribution of service populations, particularly in regional and remote contexts. Regional and remote towns are especially important locations for Indigenous service delivery. Regional towns often are destinations for temporary residents who require access to specialist services or retail and recreational facilities, but whose primary connections lie elsewhere in smaller locations. Indeed, the Council of Australian Governments (COAG) *National Urban and Regional Service Delivery Strategy for Indigenous Australians* (2009) identifies a need to better define the catchment areas of such regional centres and to develop options for measuring the scale and composition of temporary population flows that are associated with them. In order to estimate service populations, it is first necessary to clearly conceptualise them. This paper provides a critical overview of the literature on service population estimation as the first step in identifying key concepts and methods for measurement. It then proposes a new method for estimating service populations from administrative data that addresses some of the limitations of previous efforts.

There is no dominant method currently used for quantification of service areas or the estimation of service populations of various government services in Australia. The last national-level investigation into this matter of which we are aware was a pilot study conducted by the ABS (1999). The ABS sought to estimate at the Local Government Area (LGA) level the use of all 'services and facilities generally provided... [by] permanent or temporary residents of the area from which the service is sought.' The method investigated by the ABS was to search for what

Smith (1989) calls 'indirect' measures of population at the LGA level that might indicate the level of service utilisation. Among the 40 metrics considered were 'indicators of household or personal consumption: including water, electricity, gas telephone and automatic telling machine usage and retail sales of items such as petrol, milk, bread, newspapers, cigarettes and alcohol' and 'indicators of waste production: including wastewater (or sewage) flows and volumes of refuse'. No indicators were found that met the ABS criteria of national generalisability and coverage, LGA-level availability, data frequency and availability. This led the ABS to conclude that generic indicators do not provide a feasible basis for the estimation of service populations. Instead they recommended that specific population components (e.g. residents, tourists, fly-in/fly-out workers) be calculated separately.

In this paper we make a conceptual argument that the ABS pilot study, or indeed any attempt to develop a single measure of service populations for all services at a place, is likely to meet only limited success. From a geographic perspective, access to services and the concomitant service areas and populations have multifaceted determinants, incorporating spatial, temporal, social, cultural, economic and regulatory dimensions. Conceptually, service populations are determined by service consumers' choice to access services, and where and when they chose to access them. Such choices are in turn influenced by residency, temporary movement and the spatial distribution of services themselves, as well as the myriad of other factors alluded to above. Crucially, because the spatial distribution of service access points differs between goods and services, service populations should be considered individually for each service. Catchment areas for different goods and services are likely to be heterogeneous and multi-layered. Equally, differing needs, mobility, and the variable economic resources of individuals and communities mean that even for individuals living in the same location, service access patterns will differ. Attempting to develop a single measure of service area for all goods and services and for all populations is therefore problematic. Instead, we argue that service populations should be considered on a service-by-service basis.

The already considerable challenge of estimating service populations is especially pronounced in the Indigenous context for three reasons. First, the undulating nature of the general population movement across the settlement system is especially pronounced for Indigenous Australians. For example, research spanning 15 years has shown that compared to their non-Indigenous counterparts, Indigenous Australians are more likely to be away from their home on census night (Biddle & Prout 2009; Taylor 1998). Yet characteristically, links to land and kin may make Indigenous people less likely to permanently

migrate (Morphy 2007b). Second, Indigenous people are disproportionately likely to live in remote locations where service areas are larger, temporary mobility rates are greater and consequently service populations estimates are both more important and more complex. Third, the estimation of Indigenous-specific service populations requires Indigenous specific data, both in terms of population estimates and service use records. While in the past Indigenous identification has been limited, much progress has been made in recent years to redress the historical invisibility of Indigenous people in statistical and administrative data collections. Nevertheless, the need for reliable Indigenous identification remains a limitation on the availability of data sources for Indigenous population estimates. Consequently, despite a handful of localised studies, little is known about service populations or how to measure them, especially in the Indigenous context.

In this paper, we propose a new direction for Indigenous service population estimation. We first critically review the existing literature regarding service population estimation in Australia. We suggest why previous approaches have been unsuccessful in their attempts to quantify service populations. We then discuss studies of Indigenous service population, and the particular challenges of estimating service populations for Indigenous Australians. We argue that a service-oriented approach might best advance the estimation of Indigenous service populations and present a method for producing such estimates from administrative data. This work is part of the Indigenous Population Project hosted by the Centre for Aboriginal Economy Policy Research (CAEPR), which has developed a comprehensive framework for understanding and interpreting the dynamics of Indigenous temporary mobility practices across Australia (e.g. Biddle & Prout 2009; Prout 2008a, 2008b; Prout & Yap 2010; Taylor 2006).

The case for estimating service populations

Since 1981, Australia's population has been defined in terms of the number of usual residents (de jure population) rather than the number of people present at a particular time (de facto population) (ABS 2009). This change was made largely for the pragmatic reason of ensuring consistency between two components of population estimates: census data, and overseas migration data that is collected on a usual residence basis (ABS 2012). While such definitional consistency is important, ERPs fail to meet the needs of many service providers, especially those in sectors such as employment services, health-care services, child-care services, and transport, water and sewerage provision (ABS 1996). This is because these services are utilised by both residents and non-residents alike. Indeed, Charles-Edwards, Bell and Brown (2008) argue that the usual resident framework has created an

almost exclusive focus on where people live and thus obscured consideration of where people actually are. While where people are is of primary concern in producing service population estimates, it is fair to say that this should also include some measure of spatial demand generated by usual residents.

Accordingly, a de facto measure of population may be more appropriate for estimating service populations. The high level of population mobility obscured by ERPs means that such estimates are of little utility to some data users, especially those needing estimates for small geographic areas (ABS 1996). However, as the census provides a snapshot of the population at one point in time, even a de facto measure of population is insufficient as it fails to capture periodic population fluctuations involving these non-residents that occur on a daily, weekly or seasonal basis and that ultimately change the demand for services at any given location (ABS 2008). As such, the ABS (2008) recognises that further research is needed to produce a framework for the estimation of service populations.

Defining service populations

In a general sense, the term service population is literally what it implies—that population which creates a demand for services in a particular location (Taylor 2004). However, the concept of service population has no standard accepted definition (ABS 2008). While a number of working definitions exist (see Zhao et al. 2007), the ABS (1996: para 2) defines a service population as 'the total population who demand goods or services from providers in a certain locality; such persons may be permanent or temporary residents, daytime visitors, commuters, overnight or short-term visitors to an area'. Because temporary mobility may result in persons moving in and out of a catchment area, service populations are often defined in terms of an 'average' population (e.g. Taylor 1998), implying that they should be measured as a rate in units such as person-days per year.

To cover the possible range involved in terms of service population numbers, it is useful to consider two other population levels: a base population and a potential population. The base population is comprised of usual residents (including absentees) and visitors present in a location at a given point in time over a 12 month period. This is the number that would be counted if one were to conduct an enumeration of persons present on any one day plus absent usual residents. The potential population, on the other hand, is the number of persons who could be accommodated in that location. It is the sum of usual residents (de jure population) plus the maximum number of temporary residents able to be accommodated in each household (Taylor 2003). This measure is conceptually analogous to summing resident populations and maximum

accommodation capacity in studies of tourist destinations in order to estimate maximum 'carrying capacity' (ABS 1999; Bell 2004). Because the maximum number of people who could be accommodated in private dwellings does not have a clear natural limit, estimates of peak population have been used instead. To establish peak population for private dwellings requires an indication of de jure numbers as well as an estimate of the total flow through a given place over a given period. Data for even this proxy measure are difficult to obtain, and specialised household surveys may encounter problems of respondent recall. The tendency, then, where administrative data on flow through are not available or are unreliable, has been to sum the largest number of persons present in households at any one time over 12 months. The potential population has generally been found to be larger than the base population. Questions remain, however, about whether this potential number should be considered the service population or whether the service population figure properly lies somewhere between the base and the potential population estimates (Taylor 1998). Of course, if the interest is in demand for specific services, then these numbers and their associated spatial catchments will vary accordingly.

When considering specific services, it is important to differentiate between the consumer service population (i.e., the population already accessing a service) and the latent service population (i.e., the population who might potentially access a service within a service area).¹ There may be a substantial difference between these populations either when the service is not universally demanded or accessible, or when levels of service provision fail to meet demand. In this paper, we consider 'service population' to refer to the latent service population.

Previous attempts to estimate service populations

While there is no established method for producing service population estimates, the ABS (1999) outlined three potential avenues for estimation of service populations: the generic indicators approach, the carrying-capacity approach and the components approach.

The generic indicators approach

The generic indicators approach seeks to find a proxy measure that can be used to estimate service populations indirectly. This method is based on the premise that a rise or fall in the total population being serviced in a given area will create a corresponding rise or fall in certain generic indicators (ABS 1999). Indicators of household or personal consumption include water, electricity, gas, telephone and

automatic teller machine usage and retail sales of items such as water, petrol, milk, bread, newspapers, cigarettes and alcohol. The ABS (1999) investigated a range of generic indicators and found that, in general, waste production indicators seemed to be more useful than consumption indicators for estimating service populations. Waste-water flows and refuse disposal at the landfill site have some potential as generic indicators but the quality of these data were found to vary dramatically from place to place. Of the consumption indicators, milk consumption was found to be one of the more promising indicators. It was argued that milk is a commodity that is consumed by most people, regardless of their location, age, sex or other socio-demographic characteristics, although little evidence was given to support this proposition. However, obtaining data on milk consumption would require information to be collected from all milk outlets in a given area—a laborious and costly task. Other consumption indicators such as water, which have been shown to hold promise for estimating population changes at the local level (e.g. Pholeros, Rainow & Torzillo 1993), are similarly unfeasible at the State and national levels due to inadequate data collection (ABS 1999) and the documented substantial regional variation in per capita consumption (e.g. Willis et al. 2009).

The generic indicators approach was ultimately rejected by the ABS because no indicator could be found that had universal applicability and for which comprehensive data were available. More fundamentally, however, this approach relies on the questionable assumption that a good (e.g. milk) can be found which is consumed in equal quantities by all groups of the population.

The total carrying capacity approach

As noted above, the total carrying capacity approach seeks to estimate the maximum population who might be present at a given location. This is measured by the sum of the resident population and potential peak visitor numbers. Census data and the Survey of Tourist Accommodation (STA) have been identified by the ABS as potential data sources for estimating total carrying capacity (Department of Local Government, Planning, Sport and Recreation (DLGPSR) 2006). The limitations of this approach include the use of a peak rather than average measure of population (meaning that the total carrying capacity of Australia would sum to more than the total Australian population) and the exclusion of visitors staying in private dwellings.

The population components approach

The components approach to service population estimation seeks to separately enumerate the resident and visitor components of the population at a service centre, combining ERPs with a suite of measures of temporary mobility (ABS 1996). Measures of temporary mobility assessed by the ABS (1999) included tourists, fly-in/fly-out workers and commuters. This method has enjoyed some popularity in public health research, for example, where it has been used to estimate denominators for per capita measures of alcohol consumption (e.g. Catalano et al. 2001).

The components approach is subject to two significant constraints. First, it requires each of the temporarily mobile subcomponents of the population to be identified and measured. While this may be achievable for some groups using readily available data (e.g. commuters using census data), other groups such as those staying in private dwellings are more difficult to enumerate. Second, absent residents must be accounted for in order to maintain population equilibrium. As Smith (1989: 435) explains, 'while the actual population of one area is swelling with temporary residents, the actual population of another is declining because of the temporary absence of permanent residents'. This is problematic because, while potentially useful temporary mobility data sources such as the Survey of Tourist Accommodation provide highly detailed information about tourist arrivals, they do not measure geographic point of departure.

Estimating service populations in the Indigenous context

While the estimation of service populations is currently an open research question in the general population of Australia (ABS 2008), estimation in the Indigenous context is particularly important and subject to unique challenges. First, as will be discussed, Indigenous persons are more likely to be away from their usual residence when compared to the general population, bringing the issue of temporary mobility into sharper focus. Second, such temporary mobility is in some cases difficult to measure as relevant data collections may not record Indigenous status. Third, standard datasets such as those used by the ABS (1999) to investigate tourist accommodation or fly-in/fly-out workers may be of limited value in quantifying Indigenous mobility. However, in the limited literature regarding Indigenous service populations, Indigenous temporary mobility looms large.

Indigenous temporary mobility

Despite a well-developed ethnographic literature regarding Indigenous temporary mobility (e.g. Beckett 1988; Birdsall 1988; Hamilton 1987; Morphy 2010; Peterson 2004; Smith 2000; Young & Doohan 1989), only rarely have attempts been made to quantify it. Furthermore, the few quantitative studies to date have been confined to small and disparate population groups (Taylor 1998). In general, attempts to quantify Indigenous temporary mobility involve weekly or monthly household population counts but provide an indication of neither individual rates of movement, nor the sequences that they follow (Taylor 1998).

While Aboriginal spatial practices may be characterised by high mobility within specific mobility regions (Memmott, Long & Thomson 2006; Young 1990), deep and enduring attachment to country and kin can result in a form of 'immobility' (Morphy 2010). Mobility regions can be defined by a mix of social and economic factors such as the location of kinfolk, traditional associations to land, conflict avoidance, deaths in a community, availability of alcohol, recreation, employment opportunities, and the need to access services (Taylor 1998). Movement within these mobility regions tends to be circular encompassing 'beats' of family members in nearby towns and more distant places who will provide hospitality (Beckett 1988). In this way, Australia's Indigenous population tend to live between a network of places rather than having a single usual residence (Taylor & Bell 1996b). Movement within these networks is key to maintaining relationships to country and kin and is motivated by a variety of socio-cultural, economic and political factors (Memmott, Long & Thomson 2006). Based on the study of the Yolgnu people of north-east Arnhem Land, Morphy (2007b) has developed an anchored network model of Aboriginal mobility consisting of an ontologically prior sacred geography and associated settlements to which kin-based networks are anchored by nodal individuals.

Indigenous temporary mobility studies have largely focussed on regional and remote Australia (Biddle & Prout 2009). Much of this research has been ethnographic, involving biographic and contextual analysis of movement (Taylor 1998). Young and Doohan (1989), for example, conducted a process analysis of Indigenous population movement in central Australia. They employ participant observation techniques to provide cameo examples of the interplay between cultural, social and economic factors and circular patterns of mobility with an emphasis on establishing the 'setting' and 'situation' of movers at different points in time. Taylor (1988) examined rural-urban migration in Katherine, Northern Territory, and identified a range of push and pull factors operating in both urban and rural areas to generate frequent circular population flows. Prout has explored a disjuncture between the way in

which government services are delivered in Australia and Indigenous spatial practices in some depth (see Prout 2007, 2008a, 2008b; Prout & Yap 2010). Service delivery policies and frameworks have failed to adequately incorporate understandings of Aboriginal mobility processes at the State and Federal levels (Prout 2007). Also contributing to the tension, service delivery policies and frameworks are based on assumptions about 'appropriate' and 'normal' spatial practices: namely that people live sedentary lives (Prout 2007). Current government service delivery models are characterised by a 'hub and spoke' configuration where services are concentrated in urban centres and connected to smaller service outposts in regional and rural areas (Prout 2007). Investment is also directed into fixed infrastructure such as housing, hospitals and schools. According to Prout (2007), this model privileges sedentary and urban-based lifestyles and creates an awkward juxtaposition of Aboriginal spatial practices and the delivery of basic government services to Aboriginal populations. But the relationship between Aboriginal mobility and service delivery processes needs to be framed as dialectical: Indigenous mobility is influenced by service delivery and service delivery is influenced by Indigenous mobility. The assumption that Aboriginal mobility simply disrupts effective service delivery is inaccurate because the provision of services exerts influence over and is influenced by Indigenous mobility practices (Prout 2007).

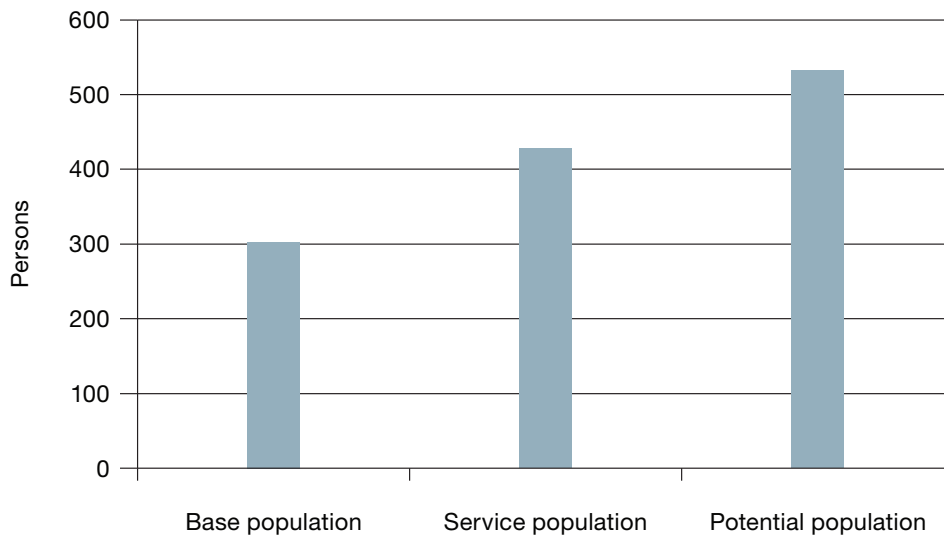
Quantitative analysis of Indigenous temporary mobility in Australia have drawn primarily on either census data (e.g. Biddle & Prout 2009; Taylor 1998) or small-scale community surveys or case studies (e.g. Foster et al. 2005; Memmott, Long & Thomson 2006; Palmer & Brady 1991; Smith 2000; Warchivker, Tjapangati & Wakerman 2000). A key study of Indigenous temporary mobility using census data is Taylor's (1998) analysis of Indigenous short-term mobility. Drawing on data from the 1991 Census, Taylor (1998) compared place of enumeration and place of usual residence data. It was found 18,186 Indigenous Australians reported being away from their place usual of residence on census night; this represents 7 per cent of the Indigenous population (Taylor 1998). Using a matrix of 54 regions which largely align with the boundaries of the 60 original Aboriginal and Torres Strait Islander Commission (ATSIC) regions, Taylor (1998) examined the population flows in and out of each region. This revealed that 57 per cent of the 18,186 Indigenous people who were counted away from their usual place of residence were involved in relatively local moves within the same region (Taylor 1998). Forty-three per cent of those counted away from their usual residence had moved between Indigenous regions, with most short-term moves being between non-metropolitan and major-city regions (Taylor 1998). While regional centres in northern Australia tended to have the highest rates of net gain, in each case this temporary receipt of population in urban areas reflected the distribution of social services (e.g. hospitals,

prisons and government offices), as well as the spatial concentration of employment opportunities and State and Territory public housing, education and training institutions (Taylor 1998). Further analysis of the same data revealed that while Indigenous temporary population movements were oriented around capital cities, shorter regional trips were more common for Indigenous movers compared to their non-Indigenous counterparts (Taylor & Bell 1996a).

Building on Taylor's (1998) work, Biddle and Prout (2009) present a snapshot of Indigenous mobility derived from the 2006 Census. The census once again identified relatively high rates of temporary mobility among the Indigenous population. It found that 7 per cent of the Indigenous population were enumerated away from their place of usual residence in 2006 compared with only 4 per cent of the non-Indigenous population (Biddle & Prout 2009).² Furthermore, Biddle and Prout (2009) identified Indigenous Australians in urban and regional areas as having similar or slightly higher levels of temporary mobility than the non-Indigenous population. Geography was found to be an important predictor of temporary mobility. Indigenous people were increasingly mobile in outer regional and remote areas, with those enumerated in very remote areas 1.2 times more likely to be visitors compared to those enumerated in major cities (Biddle & Prout 2009). Patterns of Indigenous temporary mobility were also found to differ by gender, life-cycle stage and remoteness. Biddle and Prout (2009) conclude that the census can only crudely outline the factors that drive and shape Indigenous temporary movement.

Illuminating one type of temporary movement, the journey to work, Biddle (2009) explored census place-of-work data for the Indigenous population. After controlling for the differences in Indigenous and non-Indigenous population distribution across Australia's settlement structure, Biddle (2009) found that Indigenous Australians were slightly less likely to leave their area for work than their non-Indigenous counterparts. Nevertheless, Indigenous Australians, on average, travelled 27 kilometres to work compared with 21 kilometres for the non-Indigenous population (Biddle 2009). Of those Indigenous Australians who travelled outside their area of usual residence for work, those in remote areas travelled the furthest distance and those in cities travelled the shortest distance (Biddle 2009).

A notable limitation of census data in the Indigenous context stems from the assumption that each individual occupies a single, fixed usual residence (Bell & Ward 1998). Usual residence is defined by the ABS as that place where a person has lived or intends to live for 6 months or more. This assumption overlooks alternative living arrangements and questions have been raised about the appropriateness of the usual residence concept for Indigenous Australians based on the observation that many Indigenous people

FIG. 1. Population estimates for the Bagot community, 1986

Source: Taylor 2003.

reside in an 'area' within which they are more or less permanently mobile (Taylor 1998). Concerns have also been raised around the capacity of official statistics to represent Indigenous social reality, particularly in remote Australia (Rowse 2010; Taylor 2009). The effect of measuring one set of social, cultural and economic systems using the tools, methods and purposes of another remains largely unknown (Taylor 2009). In light of the shortcomings of the census, Morphy (2007b) calls for supplementary measures of Indigenous temporary mobility that render the dynamic nature of these movements more statistically 'legible to the state'.

The reliability of census data regarding the Indigenous population has also been called into question. Census data regarding Indigenous populations continues to be constrained by issues of coverage and accuracy. Although there has been an increasing effort by the ABS to ensure the Indigenous population is accurately reflected in the census, undercount of Indigenous Australians particularly in remote areas remains an issue. Taylor and Biddle (2008) analysed the undercount in their baseline regional analysis of 2006 Census data and concluded that in many areas the 2006 Census might be more appropriately conceptualised as a sample of the Indigenous population rather than a census of the whole population. In an earlier study, Martin and Taylor (1996) analysed the 1986 Census in Aurukun, Cape York, and calculated a 17 per cent undercount. They found people who were 'missed' tended to be young, more mobile and more socially marginalised (Martin & Taylor 1996). Nevertheless, the census remains the only comprehensive source of information for Indigenous service population estimation

Estimating Indigenous service populations using household surveys

Efforts to transcend the limitations of census data for Indigenous service population estimation have tended to rely on household survey methods. Such studies have examined service population using a variant of the components approach, separately enumerating the number of residents and visitors present in a settlement at a given time. The drawback to this procedure is that conducting new purpose-designed household collections requires a considerable investment of time and resources. Consequently, there are very few existing studies. There are, however, additional benefits to Indigenous population surveys that may warrant new household surveys, particularly where the survey is controlled by Indigenous community members themselves. The Yawuru people, for example, have conducted their own survey of the Aboriginal population of Broome in conjunction with the Kimberley Institute (Taylor et al. 2012). As the community owns the data, they can use this information to lobby for appropriate resource allocation, plan for effective service delivery and canvas a range of social and economic issues facing Yawuru people.

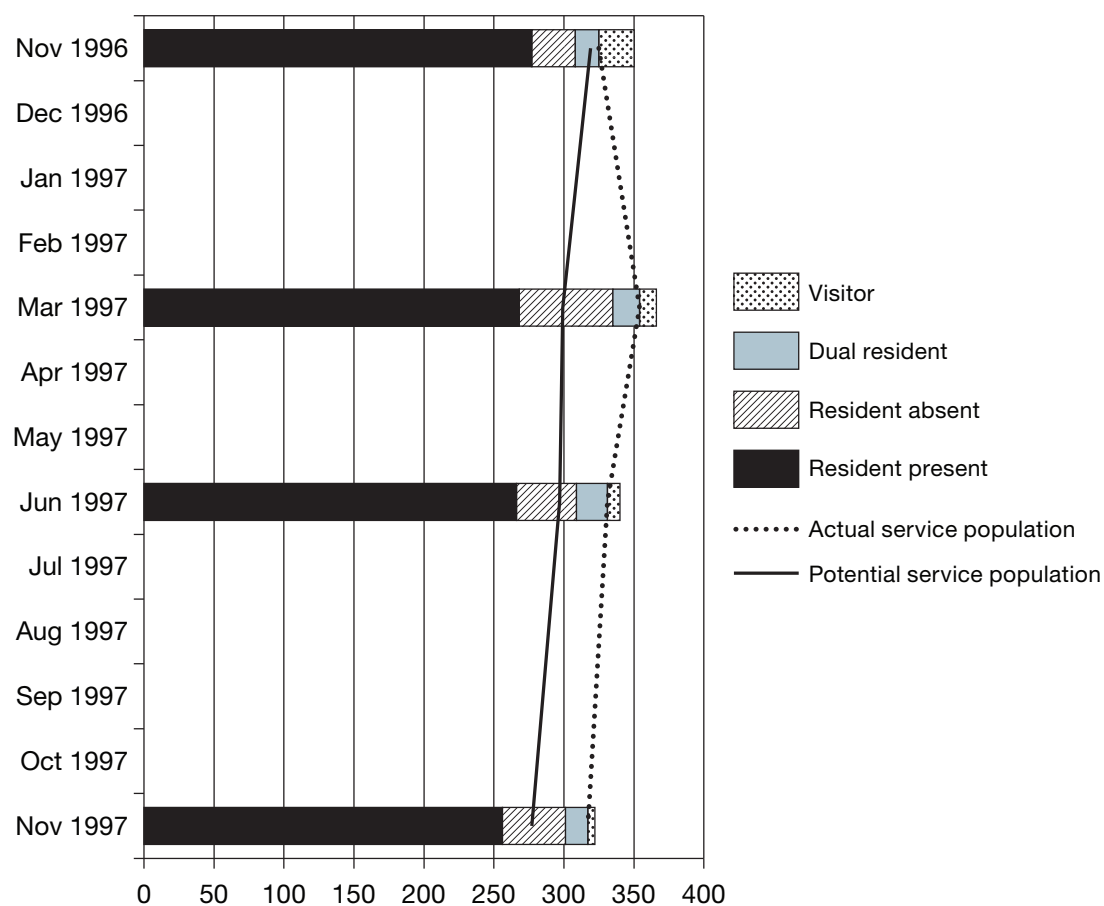
Taylor's (1986) population survey of the Bagot community in Darwin furnishes an early example of Indigenous service population estimation. Using household survey methods Taylor (1986) produced base, potential and service population estimates (Fig. 1). Compared with the base population, the service and potential population estimates were considerably higher (41% and 75% respectively). Clearly, the average population throughout the year (estimated using data on the volume and frequency of

TABLE 1. Population count of an Aboriginal community in Central Australia, over 12 months, 1996–97

	Resident present	Resident absent	Dual Resident	Visitor
Nov. 1996	277	31	17	25
Mar. 1997	268	67	19	12
Jun. 1997	266	43	22	9
Nov. 1997	256	45	16	5
Average	267	47	19	13
Standard deviation	7.5	15	2.3	7.5

Source: Warchivker, Tjapangati & Wakerman 2000.

FIG. 2. Resident and population classification of an Aboriginal community in central Australia over 12 months, 1996–97



Source: Warchivker, Tjapangati & Wakerman 2000.

TABLE 2. Estimate of population in Alice Springs town camps, 2004–05

	Jun 2004	Oct 2004	Mar 2005	Jun 2005
Residents	710	961	934	1,099
Visitors	194	239	117	227
Estimate of people not surveyed	624	324	490	385
Total population estimate	1,530	1,558	1,601	1,726

Source: Foster et al. 2005.

household visitors through the year) is markedly higher than the population encountered in Bagot at the time of the survey. Furthermore, there are times when the population is potentially 75 per cent higher than the base population (Taylor 2003).

Warchivker, Tjapangati & Wakerman (2000) investigated population mobility in an Aboriginal community in Central Australia. Four snapshot surveys were conducted over a 12 month period to capture seasonal variation in population size. Each survey also covered a period of three weeks to identify short-term variations. Information obtained from the 'house boss' included name, estimated age, residency status, reasons for absenteeism from the community (in the case of absent residents) or presence in the community (in relation to visitors) and residency status in the two weeks prior to the survey. Four mutually exclusive residency categories were constructed in consultation with community members: resident present (a person who regards this community as their main home); resident absent (a usual resident temporarily visiting another area); dual resident (a person who lives in the community but also spends significant time in another community they regard as home); and visitor (a person from another community who is transient in this community. Table 1 demonstrates the variation in the number of individuals counted in each four residency categories over the course of the year. Warchivker, Tjapangati and Wakerman (2000) argue the level of mobility reported in the four surveys is not reflected in ABS census figures. Based on Warchivker, Tjapangati and Wakerman's (2000) findings, Fig. 2 reflects compositional change in the population throughout the year and associated fluctuations in actual and potential service population size.

Warchivker, Tjapangati and Wakerman (2000) have estimated a core population of people who were present in the community for at least two surveys. This relatively 'non-mobile' population was estimated to be 74 per cent of the actual service population and 65 per cent of the potential service population. This suggests that between 26 and 35 per cent of the population engaged in inter-community mobility (Warchivker, Tjapangati & Wakerman 2000). Using

the concept of potential service population, the population denominator for resource allocation is at least 10 per cent above the ABS census figure in this community. Warchivker, Tjapangati and Wakerman (2000) conclude the ABS census does not provide sufficient information on which to base resource allocation decisions.

Drawing on a similar methodology, the Tangentyere Council investigated population mobility in the town camps of Alice Springs (Foster et al. 2005). Concerned that ERPs from the ABS were a poor reflection of the town camps population, the council conducted four population surveys of all people living in the 19 town camps in Alice Springs over a 12 month period commencing in June 2004. Aboriginal residents in public housing were also included in the survey. Just as in Warchivker, Tjapangati and Wakerman's (2000) study, information was collected from the 'house boss' regarding name, age, other people who stayed in the house, duration of stay, where people were from and where they stayed last. In each of the four surveys, a number of dwellings were not surveyed due to sorry business or residents not being at home and a small number of residents refused to take part. As such, estimates of people not surveyed were included in total population estimates. The ABS census estimate of people living in town camps in Alice Springs in 2001 was 973, considerably less than the population estimates produced by Tangentyere Council as shown in Table 2. The findings of Foster et al. (2005) also reflect considerable variation in resident and visitor populations throughout the year.

The household survey method of service population estimation is subject to several limitations. Most importantly, the reliance on the collection of primary data means that producing national estimates would require a new national survey or modifications to the ABS Census of Population and Housing. Furthermore, while the designers of household survey studies have been careful to design their studies to more appropriately fit Indigenous constructs of mobility and residency, such studies are limited by their cross-sectional nature, and when multiple cross-sectional designs have been used

Case Study: Indigenous mobility in Mt Isa, Dajarra and Alpururulam

Memcott, Long and Thomson's (2006) case study of Indigenous mobility in Mt Isa, Dajarra and Alpururulam provides a rich account of spatial practices within this region. This study teases out concepts of some pertinence to the current discussion: particularly, it adds depth to the notion of mobility regions and locates access to services as a factor in the broader mobility process.

Dajarra is a small remote town with a predominantly Aboriginal population, whereas Alpururulam is an Aboriginal community established on a land excision. Mt Isa acts as a regional service centre for both communities. Interestingly this mobility region bridges the Queensland and Northern Territory border and this has implications for service delivery: namely that planning must account for visitation from another state. Conducting survey-based interviews with household heads, young people and service providers in these sites, the authors sought to ascertain movement patterns and motivations.

The findings revealed that while participants were highly mobile, movements were contained within mobility regions that were largely localised (Memcott, Long & Thomson 2006). These mobility regions were not discrete geographic regions within which members of constituent communities share common patterns of spatial circulation. Rather, an inner region of common movement was identified which encompassed the regional centre. Movement patterns of individual communities within this inner region varied according to their distinct history of past migration and particular cultural and socioeconomic linkages. Kinship was found to be the great driving force behind Aboriginal mobility in this case study. In line with Taylor and Bell's (1996b) assertion that Australia's Indigenous population tend to occupy a network of places, movements in this case study were found to be circulatory, with people visiting one or more places for a short period and then returning to their home community. Also in line with Morphy's (2010) notion of Indigenous 'immobility', it found the majority of the Aboriginal population involved in the study remained in the region of their traditional country. So while the people of Dajarra, Alpururulam and Mt Isa are exceptionally mobile by mainstream Australian standards, they are in fact relatively stable in terms of customary attachment to their home community, country and their cultural region (Memcott, Long & Thomson 2006).

In this case study, access to services was a motivating factor underlying mobility between the study regions. It was found Dajarra and Alpururulam community members visited Mt Isa for a variety of social and service reasons, the most common being funerals, sports, shopping, and to access health services (Memcott, Long & Thomson 2006). Coupled with movement into Mt Isa was movement of Mt Isa householders back to their home communities—however, the latter was less frequent. A majority of Mt Isa respondents identified service access reasons for living in Mt Isa and family members based in Mt Isa became key 'regional households' for particular families. Despite being located 920 kilometres from Mt Isa, Townsville was found to be a secondary service centre for these communities offering the next level of services, particularly specialist health services. Interestingly, very few service providers were readily able to access data on the numbers of Aboriginal people that used their service, the home-community of those people or where people had travelled from to access the service.

they have tended to be of short duration (e.g. Foster et al. 2005). As such, household surveys are subject to the same constraints as census-based studies in terms of their ability to account for variations in temporary mobility over time. Finally, household surveys do not account for short term mobility which may involve accessing services without staying overnight.

A new direction for estimating service populations?

The challenges associated with existing approaches to service population estimation are unlikely to be mitigated in the short term (see Table 3). Indeed, one shortcoming common to all the methods discussed except in respect of household surveys is that they are place oriented rather than service oriented. That is, because most of the studies discussed have been concerned with estimating temporary populations of a place, they overlook the need on the part of service providers to estimate the number of people who might access their particular service.

Indeed, there is little a priori reason to expect that the service populations of different services located at the same site will be similar. On the contrary, the effect of temporary visitors on different services varies depending on the length of the visit, the demands of the visitors themselves and spatial distribution of services at the visitors' home locations. For example, short term visitors such as tourists are far more likely to add to the service population of a grocery store than a school; visitors are unlikely to use a renal dialysis unit unless experiencing kidney disease; and visitors are more likely to access a service such as the purchase of consumer durables while visiting when they cannot access an equivalent service closer to their home. Therefore, the very notion of a singular 'service population' that might be estimated for a given place that would be relevant to all services seems problematic.

In consequence, any attempt to construct a single place-oriented measure of service population is likely to be of little utility for many of the potential users of service population estimates identified by the ABS (1996). A one-size-fits-all approach to service population estimation should not be pursued, especially for Indigenous populations. Instead, we argue that service populations should be estimated on a service-by-service basis.

In the absence of comprehensive temporary mobility data, estimation should take place using administrative datasets. We suggest these administrative datasets should be collected by service providers themselves where possible. This has the key advantage that mobile populations using services away from their area of usual residence can be enumerated. Agencies potentially holding administrative

records for the Indigenous population include the Australian Institute of Health and Welfare (AIHW); Aboriginal Medical Services; the Department of Human Services (for Centrelink and Medicare records); the Department of Families, Housing, Community Services and Indigenous Affairs; the Department of Education, Employment and Workplace Relations; State and Territory housing and education departments; schools and hospitals. The quality of administrative data compiled by such agencies, especially with respect to Indigenous identification, remains largely unknown and is likely to be crucial to the accuracy of service population estimates. Cleaning-up data and compiling a database from which service populations can be estimated will involve some investment of time and resources. Confidentiality requirements limiting access to rich but sensitive administrative datasets at appropriate geographic resolutions may also limit the precision of service population estimates. Nevertheless, administrative datasets may hold the most promise for the production of service population estimates that are policy relevant.

The potential differences between latent service populations and consumer service populations must be addressed when using administrative data (see section on defining service populations, above). Specifically, service use datasets enumerate consumer service populations, whereas latent service populations may be of more interest to service delivery coordination. In these circumstances, latent service population estimates may be arrived at using a catchment area methodology, combining datasets such as census data and administrative records that contain a user-specific identifier, the service delivery location and the usual residence of the service consumer. Such unit-record data can then be tabulated to form a matrix of service users, with service delivery locations forming one axis and residential locations the other. In order to account for the latent service population, the use of services at each residential location can be weighted by comparing the number of service users to the ERP. Some form of age, sex, and Indigenous status standardisation may be required to ensure that latent service populations are estimated with sensitivity to the fact that demand for specific services varies as a function of characteristics such as age. However, any such analysis will be subject to the limited accuracy of official population statistics and there may be a lack of uniformity between datasets, particularly with regard to geographic boundaries and frequency of estimation considerations. Therefore, latent service population estimation should be approached with caution.

TABLE 3. Service population estimation methods: challenges and shortcomings

Method	Shortcomings for estimating service populations	Shortcomings particular to Indigenous populations
Generic indicators	No data are readily available for the most promising generic indicators Consumption-based indicators are likely to be inconsistent across all population groups Cannot account for service access	No indication of Indigenous status
Components approach	Each component of the population must be estimated separately Data for components do not generally account for resident outflows Cannot account for service access	Generally no indication of Indigenous status Little data exists for Indigenous temporary mobility
Carrying capacity approach	Assumes 'peak' population at all times of year Does not account for resident outflows Cannot account for service access Does not account for day-trips to access services	No indication of Indigenous status Difficulties in estimating peak populations in private dwellings
Census data	Temporary mobility is only captured on a single night Cannot account for service access Cross-sectional design may miss peaks in temporary mobility Does not account for day-trips to access services	Indigenous people are undercounted
Household surveys	Expensive and difficult to conduct beyond small, localised studies Cross-sectional design may miss peaks in temporary mobility Does not account for day-trips to access services	The concept of a contained household may be inappropriate in some Indigenous contexts

Estimating service populations from administrative data

Potential data sources

Estimates of Indigenous service populations from administrative data are reliant upon access to an appropriate spatial data source. As service populations will differ between services, data sources are likely to be idiosyncratic to particular services and service providers themselves may be best placed to identify relevant collections (ABS 1996). Indeed, service providers may collect relevant records as part of their normal operating procedures. Consequently, it is difficult to produce a

definitive list of potential administrative data sources for service population estimation. What may be more useful is a set of attributes that data sources must record in order to produce useful Indigenous service population estimates. At minimum, three attributes must be recorded:

1. The service recipient's residential location
2. The location of the facility at which the service was accessed
3. The Indigenous status of the service recipient

In addition, much richer analyses can be conducted if the following information is provided:

4. A non-reidentifiable code that is unique to each service recipient
5. The date at which the service was accessed
6. The service recipient's age and sex

Many datasets that meet these criteria are already being routinely produced, although of course the quality of any specific estimate of Indigenous service populations will be constrained by the quality of the Indigenous identification, which is still deficient in many administrative datasets (e.g. Australian Institute of Health and Welfare (AIHW) 2010). To take but one example, the domain of healthcare, a myriad of possible datasets may be suitable (see Table 4). While each of these datasets meets the requirements specified above, their appropriateness for use as the basis for estimating health service populations will vary accord to the type of service considered and the geographic scope of the study.

Hypothetical case study: South Australian Hospital Separations data

We present a hypothetical case study of South Australian Hospital Separations data in order to illustrate the potential use of administrative data sources to estimate service populations. The South Australian Hospital Separations data contain information about episodes of care in all 139 South Australian hospitals (see Table 5). The necessary patient residence and demographic data is recorded, as is their Indigenous status, which is of acceptable quality (AIHW 2010). A unique, non-reidentifiable patient code can also be generated from the hospital separations dataset. The date, time and location of episode of care are recorded. Furthermore, various clinical attributes such as diagnoses and procedures are noted and coded according to international standards. Such data provide the necessary ingredients for hospital Indigenous service population estimation.

Indigenous consumer service populations may be derived very simply from such a dataset. All that is required in this context is the tabulation of the number of unique Indigenous patients during the desired timeframe for each hospital. A more complex tabulation can be used to investigate the age-sex profile of each hospital's actual service population. However, latent service populations are often more useful for planning and resource allocation purposes.

Before latent service population estimation can take place, however, the patients' usual residence must be converted into a suitable geographic format. As the precision of the

service population estimates depends on the precision of the geographic location of patients' usual residence, the most geographically-specific residential address possible should be supplied. The *ABS Statistical Spatial Framework* recommends converting such addresses found in administrative data to precise geo-locations using modern address-matching technology which assigns each address a latitude-longitude coordinate pair (Searle 2012). This coordinate pair could then be used directly, geographically masked or converted to an appropriate statistical geography.

After sub-setting to identify separations made during the appropriate time frame, unique tuples of the form (*hospital id; patient id; patient location; patient Indigenous status*) would be identified. For each set of hospital, location and Indigenous status, the number of unique patients would be summed to find their actual service populations. An areal balancing factor can be derived by dividing the census estimates of the Indigenous population by the number of Indigenous residents who accessed any hospital. For example, if the Indigenous consumer service population of an area was 1,000 and the census estimated an Indigenous population of 3,000 for the same area, the balancing factor would be three. The latent service population for each hospital is arrived at by multiplying its actual service population by this balancing factor. This approach should be extended to account for the non-uniform rates of service access in a population by applying the same approach in a stratified manner to the tuple (*hospital id; patient id; patient location; patient Indigenous status; patient age bracket; patient sex*). If the population count in each cell is small, a spatial rate 'smoother' (such as local empirical Bayes) may need to be employed to reduce the variance in cells with small counts.

In the case of the South Australia Hospital Separation data, this method should be repeated for each hospital procedure, or group of procedures, of interest. As not all hospitals offer the same services, the service population of hospitals may be best considered by procedure. For example, specialist antenatal hospitals may have misleadingly low service population estimates unless considered in relation to a broader analysis of maternal health procedures. Furthermore, the census-derived population denominator for such procedures needs to be carefully examined as, in this example, females of non-childbearing ages and males are effectively ineligible to receive maternal health services. Moreover, the time frame for the estimation of service populations should also be carefully considered. For example, with the opening of the first radiotherapy facility in the Northern Territory in 2010, the service population of South Australian hospitals for radiotherapy would be expected to have dropped considerably.

TABLE 4. Administrative data sources for the estimation of healthcare Indigenous service populations

Dataset ^a	Custodians	Geographic scope
Medicare Benefits Schedule claims	Department of Human Services	National
Pharmaceutical Benefits Scheme claims	Department of Human Services	National
Hospital separations	State health departments, AIHW	State collections; standardised and compiled nationally by AIHW
Non-admitted patient emergency department care	State health departments, AIHW	State collections; standardised and compiled nationally by AIHW
My eHealth Record episodes	NT Department of Health and Families, AMSANT ^b	The entire NT and SA; parts of WA
Medical Message Exchange episodes	Kimberley Aboriginal Medical Services Council	Kimberley

Notes: a. This is an indicative list of data sources that may provide a suitable basis for estimation of Indigenous healthcare service populations. It is not intended as an exhaustive list of all suitable data sources.

b. AMSANT = Aboriginal Medical Services Alliance Northern Territory.

TABLE 5. Attributes for estimation of hospital Indigenous service populations, South Australian Hospital Separations data

Attribute	Format	Description
Patient identifier	Alphanumeric code	Uniquely identifies each person in the hospital system
Indigenous status	Aboriginal, Torres Strait Islander, Aboriginal and Torres Strait Islander, Non-Indigenous or not stated	Identification as Aboriginal and/or Torres Strait Islander or not
Age	Number	Age of the patient at time of hospital admission in five year age brackets
Sex	Female or male	Biological sex of the patient
Residential address	Address string	Reported residential address of the patient
Admission date	Date	Date of admission to hospital
Hospital identifier	Alphanumeric code	Unique identifier for the hospital at which the episode of care took place
Procedures	List of alphanumeric codes	The procedures undertaken during this episode of care, coded according to the Australian Classification of Health Interventions

Extensions and limitations

The latent service population estimate concept could be extended in a number of different directions. One extension likely to be of utility for service planning is the integration of spatial variation in service demand, which can be accounted for if demand rates for different socio-demographic groups are known. For example, age-adjusted chronic kidney disease prevalence estimates could be used to estimate latent demand for renal dialysis services. Such estimates of latent service population need may then be compared to consumer service population estimates to identify areas with substantial unmet service needs.

It is important to note that estimates of the latent service population derived from administrative data assume that the demand for a good or service is inelastic relative to supply. While latent service population estimates may be extended to account for the differential demand across different demographic groups, they are unable to account for previously unfulfilled needs that are expressed only when a new service is made available or an existing service more accessible. If such a predictive analysis is desired then more sophisticated modelling based on consumer service populations is required (e.g. Ottensmann 1997).

Privacy and confidentiality concerns are paramount in all analyses based upon sensitive re-identifiable data such as health service use. While estimated service populations produced using the method described above do not in themselves have potential to re-identify individuals, the production of service population estimates requires highly detailed data, especially if demographic analysis is included. Assurances that such data will not be disclosed should be sought before service population estimates are produced.

Conclusion

In this paper, we have argued that the limited success of previous studies in identifying methods for estimating service populations (e.g. ABS 1996, 1999) results from a questionable assumption that service populations are properties of places rather than of services. Instead, service populations should be estimated at the individual service level using administrative data rather than at the town or local government area level using generic data. We presented a method and a hypothetical case study for estimating service populations from administrative data. The next step is to apply this method using real data and a number of options for such data access have been proposed.

It is apparent that neither a lack of methods nor a dearth of spatially-referenced administrative data hamper the estimation of service populations. Why then are Indigenous service populations not routinely estimated given the documented demand for them (ABS 1996) and the existence of suitable data sources? Given current trends towards spatially-enabled government (Massera, Rajabifard & Williamson 2006), the macro-policy environment would appear to be supportive of such initiatives and yet a barrier to the estimation of service populations remains researcher access to key datasets. Data custodians are often hesitant to disclose potentially sensitive data and there is a pressing need for protocols that can provide for the sharing of data in ways that provide for useful analysis without compromising confidentiality. In the context of Indigenous population analysis, of course, there is also a need to ensure that Indigenous identifiers are present in datasets and that they produce outputs of sufficient quality. It is now more than 10 years since the potentiality of spatial science collaboration between government and researchers was pointed out (Hugo 2001) and while both the science and spatial data have progressed the key issue remains access.

Notes

1. While the ABS (1999) defines latent service populations as 'potential populations', we use the term 'latent service population' to avoid confusion with the concept of potential population introduced earlier.
2. While this figure is unchanged from that derived from the 1991 Census by Taylor (1998), dramatic changes to the methods by which Indigenous Australians were enumerated, particular in remote Australia, render comparisons between the two figures problematic. See, for example, Morphy (2007a) for the different methods of enumeration used in the 2001 and 2006 enumerations in Alice Springs town camps and north-east Arnhem Land.

References

- Australian Bureau of Statistics (ABS) 1996. *When ERPs Aren't Enough—A Discussion of Issues Associated with Service Population Estimation*, cat. no. 3112.0, ABS, Canberra.
- 1999. *An Investigation to Assess the Feasibility of Producing Service Population Estimates for Selected LGAs*, cat. no. 3117.0, ABS, Canberra.
- 2008. *Information Paper: Population Concepts*, 2008, cat. no. 3107.0.55.006, ABS, Canberra.
- 2009. *Population Estimates: Concepts, Sources and Methods*, cat. no. 3228.0.55.001, ABS, Canberra.
- 2012. *Australian Demographic Statistics, Sep 2011*, cat. no. 3101.0, ABS, Canberra.
- Australian Institute of Health and Welfare (AIHW) 2010. *Indigenous identification in hospital separations data: quality report*, cat. no. HSE 85, AIHW, Canberra.
- Beckett, J.R. 1988. 'Kinship, mobility and community in rural New South Wales', in I. Keen (ed.), *Being Black: Aboriginal Cultures in 'Settled' Australia*, Aboriginal Studies Press, Canberra.
- Bell, M. 2004. 'Measuring Temporary Mobility: Dimensions and Issues', *Discussion Paper No. 2004/01*, The Queensland Centre for Population Research, The University of Queensland, Brisbane, available at <<http://espace.library.uq.edu.au/view/UQ:10557>>.
- and Ward, G. 1998. 'Patterns of temporary mobility in Australia: Evidence from the 1991 Census', *Australian Geographical Studies*, 36 (1): 58–81.
- Biddle, N. 2009. 'Location or qualifications? Revisiting Indigenous employment through an analysis of census place-of-work data', *CAEPR Working Paper No. 61*, CAEPR, ANU, Canberra, available at <<http://www.anu.edu.au/caepr/working.php>>.
- and Prout, S. 2009. 'Indigenous temporary mobility: An analysis of the 2006 census snapshot', *CAEPR Working Paper No. 55*, CAEPR, ANU, Canberra, available at <<http://www.anu.edu.au/caepr/working.php>>.
- Birdsall, C. 1988. 'All one family', in I. Keen (ed.), *Being Black: Aboriginal Cultures in 'Settled Australia'*, Aboriginal Studies Press, Canberra.
- Catalano, P., Chikritzhs, T., Stockwell, T.R., Webb, M., Rohlin, C. and Dietze, P. 2001. *Trends in per capita Alcohol Consumption in Australia, 1990/91–1998/99*, *NDRI Monograph No. 4*, National Drug Research Institute, Curtin University of Technology, Perth.
- Charles-Edwards, E., Bell, M. and Brown, D. 2008. 'Where people move and when: Temporary population mobility in Australia', *People and Place*, 16 (1): 21–30.
- Council of Australian Governments (COAG) 2009. *National Urban and Regional Service Delivery Strategy for Indigenous Australians*, COAG, Canberra, accessed 1 October 2012, <http://www.coag.gov.au/sites/default/files/national_urban_regional_strategy_indigenous_australians.pdf>.
- Department of Local Government, Planning, Sport and Recreation (DLGPSR) 2006. *Towards estimates of service populations to inform planning in small areas*, accessed 1 October 2012, <<http://www.oesr.qld.gov.au/products/publications/towards-est-service-pop>>.
- Foster, D., Mitchell, J., Ulrik, J. and Williams, R. 2005. *Population and Mobility in the Town Camps of Alice Springs: A Report prepared by Tangentyere Council Research Unit*, accessed 23 April 2011, <http://www.tangentyere.org.au/publications/research_reports/DKCRC-Report-9-Population-and-Mobility-in-the-town-camps-of-Alice-Springs.pdf>.
- Hamilton, A. 1987. 'Coming and going: Aboriginal mobility in north-west South Australia, 1970–71', *Records of the South Australian Museum*, 20: 47–57.
- Hugo, G. 2001. 'Addressing Social and Community Planning Issues with Spatial Information', *Australian Geographer*, 32 (3): 269–293.
- Martin, D. and Taylor, J. 1996. 'Ethnographic perspectives on the enumeration of Aboriginal people in remote Australia', *Journal of the Australian Population Association*, 13: 17–33.

- Masser, I., Rajabifard, A. and Williamson, I. 2006. 'Spatially enabling governments through SDI implementation', *International Journal of Geographical Information Science*, 22 (1): 5–20.
- Memmott, P., Long, S. and Thomson, L. 2006. *Indigenous mobility in rural and remote Australia*, Australian Housing and Urban Research Institute, Melbourne.
- Morphy, F. (ed.). 2007a. *Agency, Contingency and Census Process: Observations of the 2006 Indigenous Enumeration Strategy in remote Aboriginal Australia*, CAEPR Research Monograph No. 28, ANU E Press, Canberra.
- Morphy, F. 2007b. 'Uncontained subjects: "Population" and "household" in remote Aboriginal Australia', *Journal of Population Research*, 24 (2): 163–84.
- 2010. '(Im)mobility: Regional population structures in Aboriginal Australia', *Australian Journal of Social Issues*, 45 (3): 363–82.
- Ottensmann, J.R., 1997. 'Partially constrained gravity models for predicting spatial interactions with elastic demand', *Environment and Planning A*, 29 (6): 975–88.
- Palmer, K. and Brady, M. 1991. *Diet and Dust in the Desert: An Aboriginal Community, Maralinga Lands, South Australia*, Aboriginal Studies Press, Canberra.
- Peterson, N. 2004. 'Myth of the walkabout: Movement in the Aboriginal domain', in J. Taylor and M. Bell (eds), *Population Mobility and Indigenous Peoples in Australasia and North America*, Routledge, London.
- Pholeros, P., Torzillo, P. and Rainow, S., 1993. *Housing for Health: Towards a Healthy Living Environment for Aboriginal Australia*, Healthabitat, Newport Beach, NSW.
- Prout, S. 2007. *Security and Belonging: Reconceptualising Aboriginal Spatial Mobilities in Yamatji Country, Western Australia*, PhD Thesis, Macquarie University, Sydney.
- 2008a. 'On the move? Indigenous temporary mobility practices in Australia', *CAEPR Working Paper No. 48*, CAEPR, ANU, Canberra, available at <<http://caepr.anu.edu.au/publications/working.php>>.
- 2008b. 'The entangled relationship between Indigenous spatiality and government service delivery', *CAEPR Working Paper No. 41*, CAEPR, ANU, Canberra, available at <<http://www.anu.edu.au/caepr/working.php>>.
- and Yap, M. 2010. 'Indigenous temporary mobilities and service delivery in regional service centres: A west Kimberley case study', *CAEPR Working Paper No. 66*, CAEPR, ANU, Canberra, available at <<http://www.anu.edu.au/caepr/working.php>>.
- Rowse, T., 2010. 'Re-figuring Indigenous culture', in J. Altman and M. Hinkson (eds), *Culture Crisis: Anthropology and Politics in Aboriginal Australia*, University of New South Wales Press, Sydney.
- Searle, B. 2012. 'Statistical spatial framework: increasing the relevance of statistics', Seminar presented 17 July, Fenner School of Environment and Society, ANU, Canberra.
- Smith, S.K. 1989. 'Toward a methodology for estimating temporary residents', *Journal of the American Statistical Association*, 84 (406): 430–36.
- Smith, B. 2000. *Between Places: Aboriginal Decentralisation, Mobility and Territoriality in the Region of Coen, Cape York Peninsula (Australia)*, PhD Thesis, London School of Economics and Political Science, London.
- Taylor, J. 1986. 'Bagot population survey 1986', unpublished manuscript, North Australia Research Unit, ANU, Darwin.
- 1988. 'Aboriginal population mobility and urban development in the Katherine Region', in D. Wade-Marshall and P. Loveday (eds), *Contemporary Issues in Development*, North Australia Research Unit, ANU, Darwin.
- 1998. 'Measuring short-term population mobility among Indigenous Australians: Options and implications', *Australian Geographer*, 29 (1): 125–37.
- 2003. 'Data issues for regional planning in Aboriginal communities', paper presented to the Contemporary Indigenous Issues in North Australia Seminar Series, 8 May 2003, Darwin.
- 2004. *Social Indicators for Aboriginal Governance: Insights From the Thamarrurr Region, Northern Territory*, CAEPR Research Monograph No. 24, CAEPR, ANU, Canberra.

- 2006. 'The impact of Australian policy regimes on Indigenous population movement: Evidence from the 2001 Census', in , J.P. White, S. Wingert, D. Beavon and P. Maxim (eds), *Aboriginal Policy Research Conference 2006*, Thompson Educational Publishing Inc, Toronto, Canada.
- 2009. 'Indigenous demography and public policy in Australia: Population or peoples?', *Journal of Population Research*, 26: 115–30.
- and Bell, M. 1996a. 'Mobility among Indigenous Australians', in P. Newton and M. Bell (eds), *Population shift: Mobility and change in Australia*, Australian Government Publishing Service, Canberra.
- and ——— 1996b. 'Population mobility and Indigenous peoples: The view from Australia', *International Journal of Population Geography*, 2: 153–69.
- and Biddle, N. 2008. 'Locations of Indigenous population change: What can we say?' *CAEPR Working Paper No. 43*, CAEPR, ANU, Canberra, available at <<http://www.anu.edu.au/caepr/working.php>>.
- , Doran, B., Parriman, M. and Yu, E. 2012. 'Statistics for community governance: The Yawuru Indigenous Population Survey of Broome', *CAEPR Working Paper No. 82*, CAEPR, ANU, Canberra, available at <<http://www.anu.edu.au/caepr/working.php>>.
- Warchivker, I., Tjapangati, T. and Wakerman, J. 'The turmoil of Aboriginal enumeration: Mobility and service population in a central Australian community', *Australian and New Zealand Journal of Public Health*, 24 (4): 444–49.
- Willis, R., Stewart, R., Panuwatwanich, K., Capati, B. and Giurco, D. 2009. 'Gold Coast domestic water end use study', *Water: Journal of the Australian Water Association*, 36 (6): 84–90.
- Young, E. A. and Doohan, K. 1989. *Mobility for Survival: A Process Analysis of Aboriginal Population Movement in Central Australia*, North Australian Research Unit, ANU, Darwin.
- 1990. 'Aboriginal population mobility and service provision: A framework for analysis', in B. Meehan and N. White (eds), *Hunter-gatherer Demography: Past and Present*, Oceania Monograph 39, University of Sydney, Sydney.
- Zhao, Y., John, P., David, M., Hock, L. and Guthridge, S. 2007. Population Estimates for Indigenous Health Zones in the Northern Territory, accessed 23 April 2011, <<http://digitallibrary.health.nt.gov.au/dspace/handle/10137/64>>.