Chapter 12
Google Maps Mashups for Local Public Health Service Planning

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12.1 Introduction

One of the key challenges in public health service planning is to reduce health inequalities at the local level. This often entails understanding the detailed profile of a local area's population and ensuring equal access to health services. Accessibility to health services, personal behaviour and lifestyles, community influences, living and working conditions, educational attainment and health literacy can all impact upon an individual's health, and their aggregated effect is clearly manifested at neighbourhood level.

Monitoring such population's characteristics and health outcomes, and targeting health initiatives on the groups with most need has proved increasingly difficult for primary care health authorities. This challenge is especially critical in London's increasingly multicultural society, characterised by a highly transient population with ties to all over the world. Traditional planning support tools and data sources have failed to keep up with these challenges due to the rapid geographic and demographic changes occurring in London's inner boroughs at small area level since the last census of population in 2001.

This chapter describes a successful geographic visualisation tool for supporting public health service planning developed through a Knowledge Transfer Partnership (KTP) between University College London (UCL) and Southwark and Camden Primary Care Trusts in London. This tool is based on a simple implementation of *Google Maps* application programming interface (API) as a framework for geographical visualisation of the population characteristics at small area level (geographical units comprised of 285 people on average). Innovative population datasets have been developed by UCL through several collaborative projects, based on new and frequently updated information sources available at the individual level such

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as patient registers, hospital admissions, births and deaths registrations, electoral roll registrations and neighbourhood geodemographic classifications. One of these derived datasets, termed *Onomap* and which is based on the origin of people's names, estimates population counts by very fine ethnic groups at small area level, providing a rich multicultural atlas of London's neighbourhoods.

This chapter is structured in three sections, which address the content developed to meet the challenges described above, as well as technical details of the visualisation system presented here. Section 12.2 summarises the characteristics of the population datasets developed by UCL that form the core content of the visualisation tool presented here: the 'Multicultural Atlas of London', geodemographic profiling and hospital admissions. Section 12.3 describes the technical aspects of building mapping mashups and the specific solution developed for this case, the *London Profiler*. Finally, Section 12.4 offers some conclusions and proposes future avenues for research and development in mapping mashups.

12.2 Monitoring Population to Improve Primary Care Service Provision

Given the challenges in public health service planning presented in the previous section, it is clear that there is a strong need for planning support tools that allow public health planners a more effective way to understand the changing nature of the population in rapidly changing cities like London. Two general aspects are required

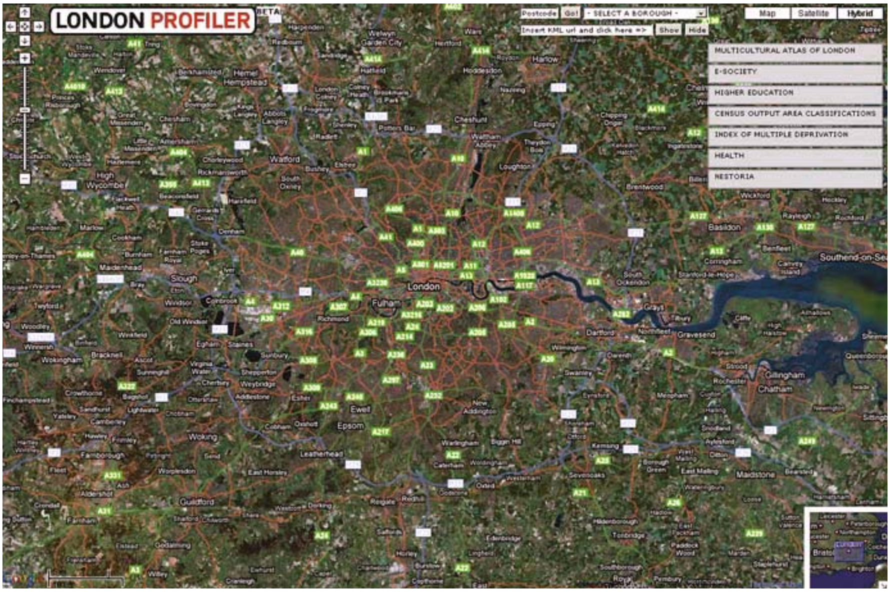

Fig. 12.1 *London Profiler*: full London view, hybrid layer (See also Plate 24 in the Colour Plate Section)

to put together such planning support tools; content and technology. This section describes the content developed for the geographic visualisation tool known as the *London Profiler* (www.londonprofiler.org) (Fig. 12.1).

This tool is comprised of a set of innovative datasets about London's population that can be frequently updated and are available at a geographically disaggregated level as to monitor changes at the neighbourhood scale. There are seven different types of population datasets included in the *London Profiler* web tool. Three of them will be introduced in detail through the next three subsections, while the four others will be summarised in Section.12.2.4.

12.2.1 Onomap: A Classification of Ethnicity Based on Names and the Multicultural Atlas of London

UCL Department of Geography has developed a new methodology to classify populations and neighbourhoods into groups of common cultural ethnic and linguistic origin using surnames and forenames (Mateos *et al.* 2007). This methodology, which is now known as *Onomap*, is a response to a growing set of pressures on national and local government to understand and identify the detailed composition of ethnic groups in today's increasingly multicultural societies. Ethnicity classifications are often hotly contested, but still greater problems arise from the quality and availability of official classifications, with knock-on consequences for our ability to meaningfully subdivide populations (Aspinall 2002). Name analysis and classification has been proposed as one efficient method of achieving such sub-divisions in the absence of ethnicity data (Nanchahal 2001), and may be especially pertinent to public health and demographic applications. However, previous approaches to name analysis have been designed to identify one or a small number of ethnic minorities, and not complete populations (Mateos 2007).

UCL's 'Multicultural Atlas of London' intends to celebrate the diversity of cultures represented in many of the neighbourhoods of contemporary London. It represents the results of an innovative initiative through which the UK Electoral Register has been classified using *Onomap* names classification. *Onomap*'s methodology is based on an alternative ontology of ethnicity that combines some of its multidimensional facets: language, religion, geographical region and culture, as encapsulated in the origin of people's forenames and surnames, used as a proxy for their probable ethnicity. It is a methodology developed using data collected at very fine temporal and spatial scales, and made available, subject to safeguards, at the level of the individual. Such individuals are classified into 185 independently assigned categories of cultural, ethnic and linguistic groups, based on the probable origins of their names (Mateos *et al.* 2007).

The UK Electoral Register is a public register that contains names and addresses of all adults that are entitled to vote, comprising over five million people in London in 2001. The version used here is from 2001, prior to a change in legislation that allowed the option to 'opt out' from the publicly available version. Using *Onomap* classification applied to the Electoral Register, the geographical distribution of 18 of the most symbolic ethnic groups in London have been mapped at output area level: Bangladeshi, Chinese, English, Greek, Indian, Irish, Italian, Jewish, Nigerian and Ghanaian, Other Muslim, Pakistani, Polish, Portuguese, Russian, Sikh, Sri Lankan, Turkish, and Vietnamese. Many of these cultural, ethnic and linguistic groups are not collected by the census of population or official surveys, hence these datasets represent an innovative approach to measuring cultural diversity in London. Furthermore, making them easily accessible to public health analysts through the visualisation techniques presented here has been a major breakthrough for local population monitoring initiatives.

12.2.2 Geodemographic Profiling of Local Population

Geodemographics is defined as "*the study of population types and their dynamics as they vary by geographical area*" (Birkin and Clarke 1998, p. 88). One of the few premises of geodemographics is the observation that we, on average, tend to have a lot in common with those living around us when we look at age, family structure, income, occupation, interests and patterns of consumption. The commercial sector has exploited this question for a number of years used neighbourhood or geodemographic classifications for direct mailing and market analysis. The characteristics of different neighbourhood types discerned from geodemographic classifications are sometimes summed up in the concept of 'lifestyle'. The public sector has recently started to embrace geodemographics and lifestyle management, since it is deemed to bring a better understanding of the local neighbourhoods in 'tailoring' services and highlighting areas of particular interest or concern (Longley 2005). The field pioneering this adoption has been public health, where geodemographics has supported actions to reduce inequality of health outcomes and access to services, such as, for example, targeting patients with information about healthier choices and the location of local facilities.

The Office for National Statistics (ONS) has developed geodemographic classifications of neighbourhoods from both the 1991 and 2001 UK censuses, the latter termed the Output Area Classification or OAC (Vickers and Rees 2007). OAC comprises a comprehensive and accessible neighbourhood classification that allows users to perform geodemographic analyses free of charge through a robust and transparent methodology. A single national system like the OAC enables a level of comparison across the country, so that, for example, large surveys can be projected to most areas. Yet in our experience, for the planning health services at a local level in the inner-city boroughs of London, OAC appears overly vague, with swathes of central London ascribed to a single dominant 'Multicultural' category. This suggests that London on the whole is very different to the rest of the country and that a national system comes with a substantial loss of local variability. In order to tie in OAC with our work with public service data, we decided to modify the OAC to produce the London OAC or LOAC (Petersen *et al.* 2007). This is based on the

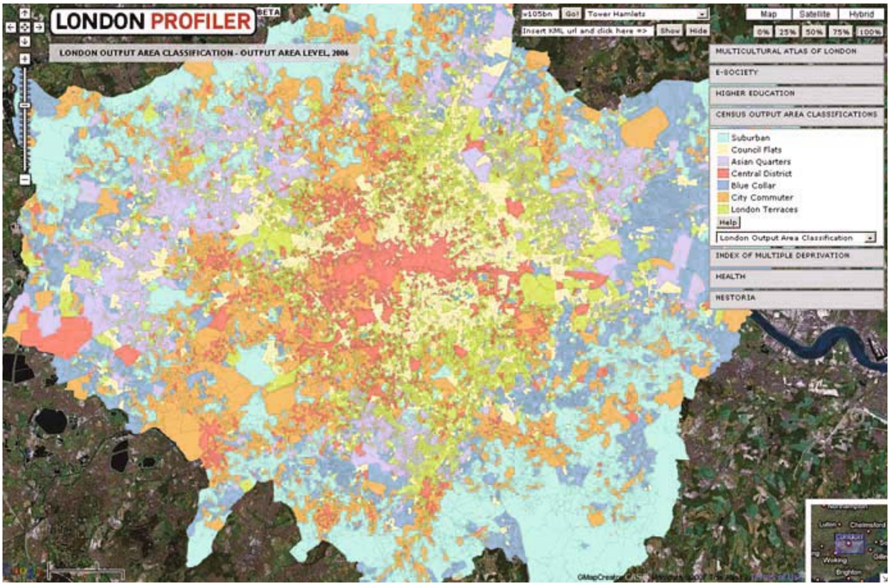

Fig. 12.2 *London Profiler*: full London view, London Output Area Classification layer, 100 per cent transparency, satellite layer (See also Plate 25 in the Colour Plate Section)

same methodology as OAC with regards to input variables and clustering algorithm, but focuses just on London for data and standardisation. LOAC is offered as an alternative classification of neighbourhoods, and analyses suggests that it presents a more ‘natural’ way of dividing up the city for a number of social, economic and demographic variables (Petersen *et al.* 2007).

The map of LOAC (Fig. 12.2) shows London with a core of regenerated and privately owned flats (‘Central District’) and rings with post-war social housing in apartment blocks (‘Council Flats’) interspersed with older, now part publicly and part privately owned, terraced housing (‘London Terraces’). Further from the centre, we find traditionally are more affluent and contained a higher proportion of privately owned housing (‘City Commuter’) and areas characterised by British Asian communities (‘Asian Quarters’). The outer ring consists of satellite settlements (‘Suburban’) and areas traditionally inhabited by manual labourers in the industry areas to the east of the city (‘Blue Collar’). This map of the LOAC, as well as a separate one of the OAC, have been included in the final geographical visualisation tool presented in this chapter.

12.2.3 Hospital Care Needs and Public Health Campaigns

In the UK, long-term health conditions account for 80 per cent of General Practitioner (GP) consultations, 60 per cent of hospital bed days, and 67 per cent of medical emergencies. The 10 per cent of patients with the most severe health care needs account for 55 per cent of inpatient days and the top 5 per cent of patients account for 40 per cent. In all, 17 million people in the UK are estimated to suffer from a long-term disease like arthritis, asthma, back pain, chronic airways obstruction, diabetes or diseases of the nervous system (Department of Health 2004). The problems of long-term diseases are growing alongside the ageing of the population, but the effects of lifestyle changes with richer food and less exercise is already adding to the burden of some long-term diseases, such as heart diseases and diabetes (Type 2). Reaching those population groups and individuals with the highest needs, and providing them the most appropriate level of health care, is a substantial task for health authorities. Mapping long-term needs has a significant potential not least to planners, but also for the users. For example, they can look forward to receiving treatment closer to home in community clinics, GP surgeries or indeed at home (Department of Health 2006).

Hospital admission data in the UK provide a very detailed picture of local health care needs and in this work we would like to illustrate how admission maps can be used to support public health campaigns. One of the first health themes in the *London Profiler* is diabetes risk presented as an admission ratio; i.e. the number of admissions for an area divided by the expected number were the age and sex specific rates to be the same as for the whole of London. An admission ratio of 100 is the London average; 50 is half and 200 the double. Profiling the diabetes admissions with a geodemographic system, for example the LOAC system, highlights neighbourhood types where admissions are more or less common (Fig. 12.3). Here

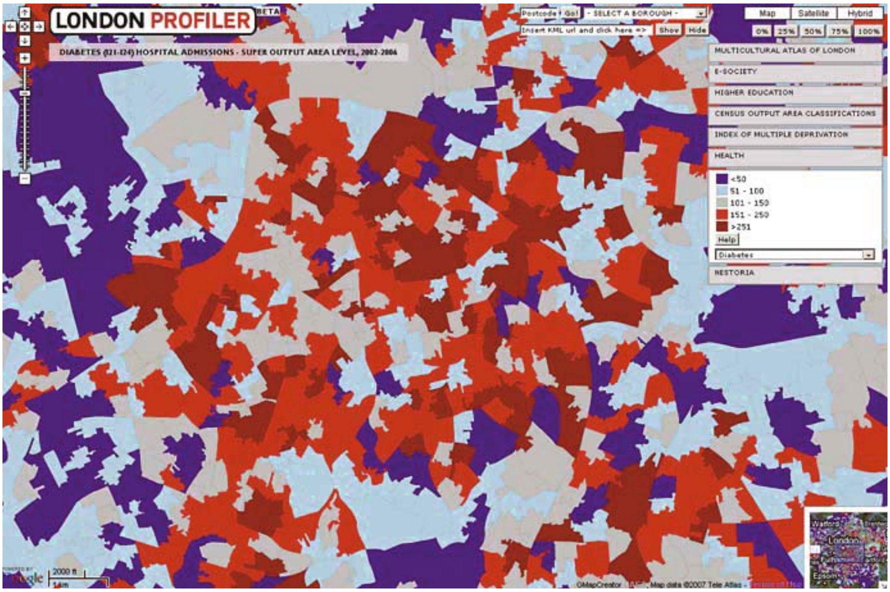

Fig. 12.3 *London Profiler*: health tab, HALT dataset, diabetes hospital admission ratio, 100 per cent transparency (See also Plate 26 in the Colour Plate Section)

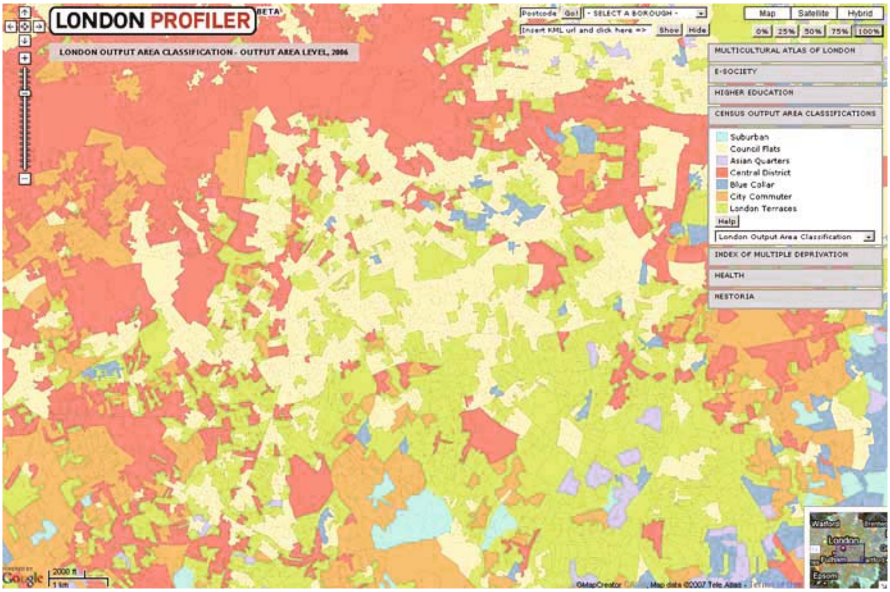

Fig. 12.4 *London Profiler*: London Output Area Classification layer, 100 per cent transparency (See also Plate 27 in the Colour Plate Section)

we see ‘Council Flats’ in particular, but also ‘Blue Collar’ and ‘London Terraces’ as having a higher risk than average (Fig. 12.4). Used in this way, geodemographics can be a reasonable way to perform exploratory data analysis of disease patterns and potentially geodemographics can also be useful providing the broader social context for diseases with a ‘lifestyle’ component.

12.2.4 Other Population Datasets

In addition to the three UCL research projects so far presented in this section, four other datasets are included in the *London Profiler* tool:

- *E-society*: a geodemographic classification developed as part of a project at UCL that presents a detailed classification of neighbourhoods based on information about levels of awareness of information and communications technologies (ICTs), usage patterns and attitudes to their effects upon quality of life. The classification provides a valuable and accessible means of studying the ‘e-society’ and people’s engagement with new information and communications technologies (Longley *et al.* 2006).
- *Higher education*: The ‘Participation Of LOcal AReas’ (POLAR) is a classification of neighbourhoods according to rates of higher education young

participation (18–19 years old). It indicates higher education participation rates at ward level shown as quintile bands. The classification was developed by the Higher Education Funding Council for England (HEFCE) and is used in the allocation of widening participation funding to HEFCE-funded institutions. In addition to the main classification which relates to absolute participation rates, HEFCE have provided a series of supplementary data at ward level which relate to participants in higher education, all of which are available on the *London Profiler* website.

- *Index of Multiple Deprivation (IMD)*: The IMD was created in 2004 by the Department for Communities and the Local Government (DCLG) as a method of identifyingdeprived areas across UK. The IMD is presented as a series of rank and scores that classify every area according to its deprivation, measured on seven different domains (Fig. 12.5).
- *Residential property data*: These are coming from a commercial property search engine called Nestoria (www.nestoria.com). This website allows the user to filter through a property database and visualise the results in *Google Maps*. Data can also be downloaded as a Keyhole Markup Language (KML) file and opened in *Google Earth*. The Nestoria tab on *London Profiler* allows replicating the process of filtering the property database and loading the KML file without the need to access the Nestoria website. Data are directly streamed from the website as a typical Web 2.0 point mash up dataset.

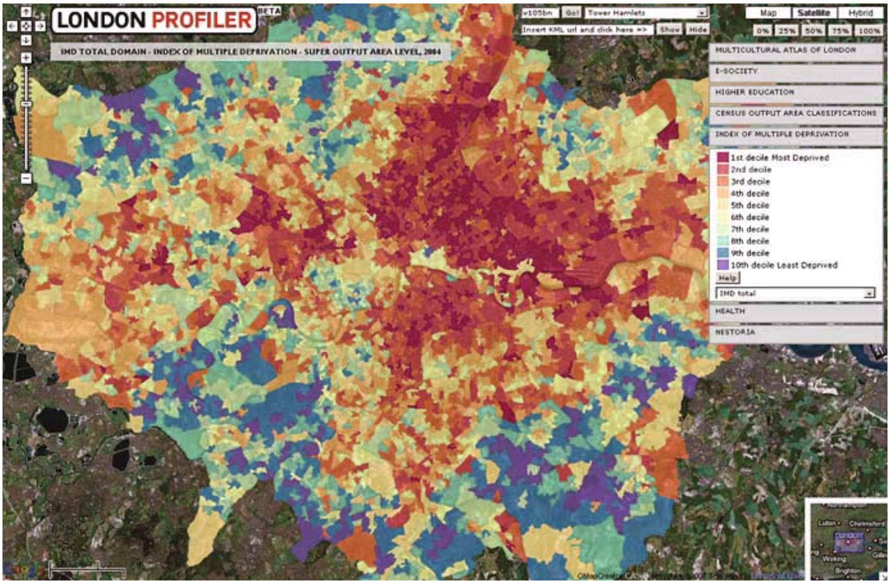

Fig. 12.5 *London Profiler*: full London view, Index of Multiple Deprivation tab, IMD total layer, 75 per cent transparency, satellite layer (See also Plate 28 in the Colour Plate Section)

Fig. 12.6 *London Profiler*: postcode level, e-society classification tab and layer with a KML file overlay from Nestoria data, 100 per cent transparency, hybrid layer (See also Plate 29 in the Colour Plate Section)

12.3 Geographic Visualisation Through *Google Maps*: Mapping Mashups and The *London Profiler*

12.3.1 Mapping Mashups

The term geographic visualisation or geovisualisation (GVis) refers to spatial data and *"can be applied to all the stages of problem-solving in geographical analysis, from development of initial hypotheses, through knowledge discovery, analysis, presentation and evaluation*" (Buckley *et al.* 2000). There is increasing realisation of the potential for 'geography' to provide the primary basis for innovative visualisation and knowledge exploration (Dodge *et al.* 2006).

GVis applications on the internet are typically offered through a type of technology developed in the 1990s commonly known as WebGIS. A WebGIS combines the features of a common geographical information system (GIS) in an internet environment using an ordinary web page as the front end. Different examples of WebGIS available on the internet cover a wide range of GIS applications, from environmental to social sciences. These websites provide users with several tools to visualise, query and sometimes edit the datasets. Nonetheless, the diffusion of WebGIS has been very limited, because of technical as well as human factors, both at the institutional level supplying the service and at the user level. Some of these limitations will be mentioned here.

First of all, the design of a successful WebGIS website requires developers with very specialised programming and database skills, as well as a great deal of work paid to the design of the end user interface. The end user must be able to access the different tools available in the WebGIS in an accessible and easy-to-use way. Second, WebGIS solutions are very expensive to develop, both in terms of software platforms (although there are also open source solutions available) and developing their content, since they usually require very expensive proprietary data, sorting out cumbersome copyright issues with geographic data for every single area of concern, and developing customised tools that are only meant for a specific vertical market.

Because of this last problem of the high cost of developing content, most of WebGIS websites offer little contextual geographic information (GI). Such contextual GI typically allows the user to intuitively relate the specialised data provided by the WebGIS (e.g. road accidents, or weather forecasts) with the geographical context in which these actually takes place. For example, in the application presented in this chapter, the specialised data to be visualised are population datasets by administrative areas in London and the GI context would be the road and public transport network, the names of the neighbourhoods and aerial photography.

The diffusion of *Google Maps* and *Google Earth* since 2005 has increased the use of GI among internet users and fuelled new ways of deploying GI in an effective and easy way that is rapidly and intuitively understood by any sort of public. Mapping mashup is a term recently introduced to refer "*to hybrid web applications that combine data or software from two or more sources*" (Monmonier 2007, p. 373). The most widely used mapping mashup technology is based on *Google Maps*, a free web service that has been deemed to "*dramatically raised users' expectations [with] its fluid movements, intuitive user experience and competent cartography*" (Fairhurst 2005, p. 57). Although *Google Maps* is not a complete GIS tool, the availability of a free *Google Maps* API stimulates people with basic programming skills to build their own applications using *Google Maps* as a visualisation interface 'mashed-up' with their own geographic data. In *Google Maps* mashups, the user's specialised data are given instant geographical context through detailed satellite and aerial imagery, place names, administrative boundaries, road and street networks and point of interest data (such as underground or rail stations), seamlessly available throughout the world.

The simple cartographic design of the *Google Maps* base layers, which are integrated into all mashups based on *Google Maps* API, make them the ideal background for thematic map overlays. *Google Maps* enable users to visualise thematic map layers made up from boundaries of unfamiliar size and location, and provided by third parties, within the context of local and scalable geographical features. Compounding essential geographic information on the 'where' with the 'what' needs careful visual design (Tufte, 1990). The colour scheme choice for the thematic overlay must avoid tones (Harrower and Brewer 2003) that can be confounded with the underlying *Google Maps*. A solution employed in the example presented in this chapter uses a combination of thematic overlay transparency and the Google 'hybrid map' layer, as described in the following section (Fig. 12.7).

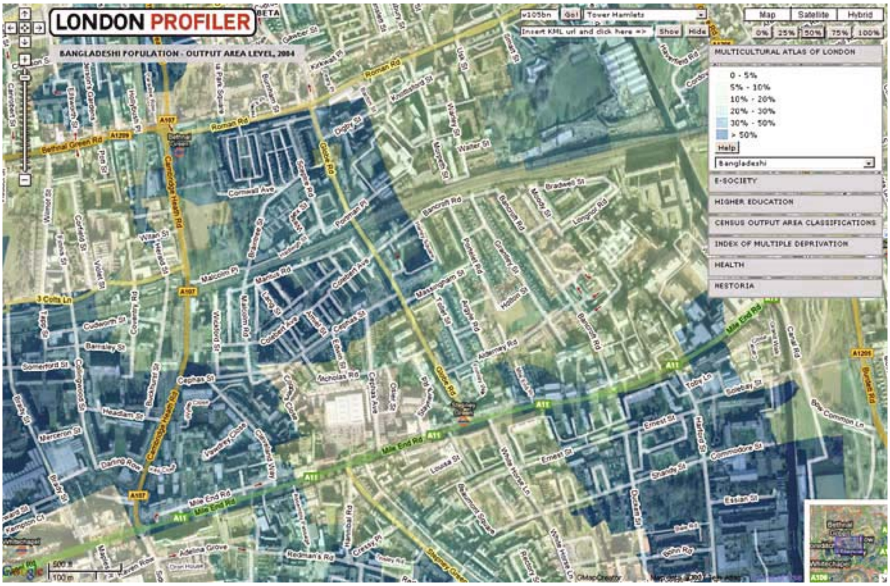

Fig. 12.7 *London Profiler*: postcode level, Multicultural Atlas of London tab, Bangladeshi population layer, 50 per cent transparency, hybrid layer

12.3.2 The London Profiler Website

The Centre for Advanced Spatial Analysis (CASA) at UCL released in 2006 a freeware application to simplify thematic mapping in *Google Maps*, termed *GMap Creator* developed by Richard Milton as part of the GeoVUE Project (a node of the ESRC National Centre for e-Social Science). This simple application takes native GIS files (typically in *shape file* format) and creates a *Google Maps* mashup in a very straightforward fashion. Users have to provide a projected *shape file* containing the data to be visualised, choosing a variable from the attribute data and a colour scheme for the final thematic map to be created. The thematic layer is transformed in a series of image tiles of equal size (256 × 256 pixels), the number of tiles being determined by the *Google Maps* zoom level selected. Finally, an *html* file is created that places the numerous tiles on top of the *Google Maps* interface using the previously mentioned API. *GMap Creator* output is a webpage that contains the mapping application in a standard format and layout.

The *London Profiler* project (www.londonprofiler.org) has harnessed *GMap Creator* to visualise population data alongside industry standard web interfaces to develop comprehensive profiles of the public that can be used by the public to understand local geographies of public service delivery. Its principal deliverable is a web tool to visualise population administrative data at small area level (census output areas), to be made accessible to a mass audience of specialist users as well as the general public via an easy to use website. The *London Profiler* project has been conceived as an initial prototype of larger future planning support systems based on mapping mashups. All the thematic maps are created through *GMap Creator* and then managed through *Google Maps* API embedded in the front-end user webpage.

London Profiler enables users to build up a picture of the geodemographics of Greater London from data on population attributes such as the distribution of cultural and ethnic groups, the level of deprivation, the extent of e-literacy, level of higher education, and health-related problems together with the free geodemographic classifications available in the UK (OAC and LOAC). Some of the datasets displayed are the result of different research projects carried out at UCL, such as the Multicultural Atlas of London, the OAC standardised to London (LOAC), Hospital Admissions for Long-Term diseases (HALT), and the e-society classification. Other datasets, such as the IMD, POLAR and residential property data, have been taken from publicly available sources. These seven domains in *London Profiler* have been fully described in Section 12.2, and duplication is avoided here.

London Profiler users can select to map one attribute within those seven domains (each of which offer different attributes to map), and focus on an area within London searching by postcode or one of the 33 London Boroughs. They can also decide to add contextual GI to the theme map being displayed, such as an area's physical environment—through the aerial photographs—and its place names and streets—through the road network and points of interest layer. Furthermore, they can change the level of transparency of the map layer being visualised in order to combine it with such contextual geographical information in more meaningful ways, depending on the zoom level at which the map is being displayed. Finally, the user might choose to add any other customised map layers through the standard Google KML file format by simply adding its internet address location to the web page (for example from a bespoke map prepared in 'Google My Maps'). Overall, the web layout of *London Profiler* is simple and very easy to use since it is targeted to the general user, and not only analysts which are used to GIS tools. Some examples of the visualisations that can be created using *London Profiler* are shown in Fig. 12.1 to Fig. 12.7.

12.4 Conclusions and Further Research

The mapping mashup visualisation tool presented in this chapter, termed the *London Profiler*, has allowed Southwark and Camden Primary Care Trusts to create a picture of their populations at the small area level, typically the census output area. This is crucial in areas such as inner London where identifying so called 'hard to reach' groups is key to reach the public health targets specified by the government. Using *London Profiler*, a number of public service planning functions can be easily supported in an inexpensive way. In this chapter we have shown one example of its application to public health service planning, in which it can support the objective of tackling health inequalities through the targeting of initiatives to the specific local population at risk or in need. This has been achieved through a very simple to use web based mapping interface, and thus accessible to any person, in this case working in a Public Health department.

The 'mashing up' of different population data with base geographic information has provided planners with an efficient tool to improve primary health care service provision and monitor General Practices' performance. The health domain in *London Profiler*, and in particular the Hospital Admissions for Long Term illnesses (HALT) dataset, can alert local health authorities and GPs about admission hotspots in their catchment areas. Such catchments areas' of GPs, which for example were created for Southwark PCT using individual level patients registration geocoded data (Gibin *et al.* 2007), can be easily overlaid on top of all the thematic layers in the *London Profiler* enabling exploratory spatial analysis between a GP's location, the catchment area of the GP's registered population, and that area's socioeconomic and demographic characteristics. The e-society classification domain also revealed to be very useful in pioneering the use of new technologies for health care service provision. By overlaying their catchment areas on top the e-society classification in *London Profiler*, Southwark Primary care Trust's GPs, were able to assess the engagement in new information and communication technologies (ICTs) of their patients, and therefore promote the use of internet booking systems for GP appointments and repeated prescriptions, as well as identifying population groups that would not be likely to use this channel.

Through the examples presented in this chapter, we have intended to present a new and innovative approach to GVis termed 'mapping mashups'. The technological platform adopted in this example is based on the freely available *Google Maps* API, but other similar technologies have recently emerged (e.g. Microsoft Local Live or Yahoo Maps).

'Mapping mashups' offer a typically free solution for online exploratory cartographic visualisation, and as such they can prove an inexpensive and effective platform for visual communication of population data such as in the public health example presented here. The *Google Maps'* graphic user interface (GUI) is very intuitive and requires hardly any guidance to the end user, be it either external or internal to an organisation. *Google Maps* mashups can be easily and inexpensively developed, offering public service institutions great time and cost saving benefits when compared to much more complex mainstream WebGIS technologies. The example of mapping mashups presented in this chapter can be applied to other service planning scenarios. Its flexible and inexpensive features clearly make it the platform of choice for the development of future planning support systems where geographical visualisation plays a central role.

Further research in this area will necessarily have to address three main challenge areas: cartography, technology and obsolescence. From a cartographic perspective, overlaying thematic data on top of a rich and detailed reference map involves different visualisation problems. The thematic map classes need to be clearly identifiable as well as the reference data underneath. A typical way of intermediate in this problem is using layer transparency to alter each layers weight and allow the visualisation of a proportion of either the thematic map or the base maps layers. The level of transparency must be specifically tuned to allow the user to distinguish between the different thematic classes displayed, in conjunction with the choice of an appropriate classification algorithm, number of classes to be used, and the colour ramps assigned to them. Another interesting cartographic issue is how to accommodate changes of geographical scale in the way data is displayed, in particular the simplification of thematic area boundaries.

Technology is another key driver in further developments of mapping mashups such as the *London Profiler*. One reason of the great success of websites based on *Google Maps*, versus those based on traditional WebGIS solutions, is the fast speed at which the map is served to the user. Most of WebGIS systems display 'on the fly' geographic information stored in the server according to a set of parameters supplied by the user. This approach is very flexible but levies the bulk of the workload on the server hosting the website, while in *Google Maps* and similar websites the workload is shifted to the internet browser. By doing so, maps are not created on the fly but hosted as pre-rendered images that are served very quickly, minimising the server workload. The major drawback of this approach is the lack of flexibility, since all the maps must be pre-rendered and stored on the server. Further research on mapping mashups, and indeed future enhancements of *London Profiler*, will have to attempt to integrate the two approaches described above. Some commercial GIS software vendors are actually moving in this direction. For example the new version of ESRI's ArcGIS Server includes a feature to create a 'cached' image version of a map for different scales so that when a user zooms to a certain scale the map tiles are served faster.

The last but most important issue of all is to prevent obsolescence and ensure an adequate level of website update in order to keep user interest. The pre-rendered map approach, as in the *London Profiler* example described in this chapter, requires an intensive amount of work to update the content of the thematic layers or to add new ones. Website longevity could also be extended by allowing users to add more content to these mapping mashups, through facilities such as the KML file overlay in London Profiler to add customised map layers, or the Map Tube project at UCL (www.maptube.org).

Mapping mashups is a recent innovation in the visualisation of geographic information whose future looks even brighter than that already enjoyed in its recent short and successful history since they appeared in 2005. This chapter has presented one example of mapping mashups applied to a local public health service planning. As discussed through the chapter, this approach offers an inexpensive, flexible, scalable and intuitive method of communicating geographical information that will most likely eventually replace traditional 'top-down' or 'turn-key' WebGIS solutions for most basic geographical exploration functions of planning support systems.

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