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Review of the Irish and international literature on health and social care unit cost methodology

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Abstract: *This literature review examines the methodologies used to calculate health and social care unit costs internationally and in Ireland. The purpose of this review is to identify the alternative approaches to unit costing for health and social care services in the literature and to assess the advantages and disadvantages of their use in an Irish context. The review finds that the use of bottom-up or top-down methods varied by type of study being undertaken. The proportion of studies that used unit costs calculated by applying a bottom-up approach was higher than the proportion using a top-down approach. Bottom-up approaches dominated when there was a greater need for accuracy in estimates, such as in health technology assessments, or when the extra data requirements of the bottom-up approach were not too penalising, such as with disease/setting specific studies. Top-down approaches were prevalent among studies that needed to estimate unit costs across a wide range of services and diseases. Top-down approaches were also more prevalent than bottom-up approaches for projection models of health and social care that used unit costs. At present, the Irish system suffers from the lack of a centralised unit, like the PSSRU in England, tasked with producing annual volumes of unit costs for health and social care. The development of comprehensive unit cost profiles for Irish health and social care services would be of significant benefit to researchers, policymakers and wider health system stakeholders.*

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1 Introduction

In Wren et al. (2017) (1), demand for health care services for each year were projected from 2015 to 2030 using the HIPPOCRATES model. To develop these projections, activity rates by single year of age and sex across each service in the base year of 2015 were calculated. Activity rates were calculated by dividing activity volumes by numbers in the relevant age cohort in the population. Population projections, as well as assumptions regarding healthy ageing and unmet need and demand, were then applied to the activity rates to estimate the projected demand for each service by males and females of different ages over the time horizon (1). The next phase in the development of the HIPPOCRATES model will involve the introduction of costs to the model to allow for the projection of expenditure over the time period. This will be accomplished by matching unit costs to the age and sex-specific activity of each health care service.

A unit cost relates to the cost required to produce one unit of a good or service. As such, unit costs can help put large expenditures into context, thereby facilitating the more cost-efficient use of resources (2). In order to develop projections of expenditure it will be necessary to know the cost related to services demanded. However, for many services that will be costed as part of this exercise, it will be necessary to develop bespoke unit costs as, unlike other systems (2), no central database of unit costs exists for Irish health and social care services. Ideally, unit costs will be disaggregated by age and sex to the same level as the relevant measure of activity. However, the unit costs to be developed for the HIPPOCRATES projection model will be significantly influenced by the quality of cost data available for specific services, which may be quite poor in certain cases. In that context, this review will provide an understanding of the alternative approaches to unit cost development that have been employed in the literature along with their relative advantages and disadvantages. This paper was undertaken as part of the ESRI Research Programme in Healthcare Reform, funded by the Department of Health.

In general, two broad methodological approaches have been identified to cost services. For the purposes of this paper, these will be referred to as a top-down approach and a bottom-up approach. Top-down approaches can also be referred to as gross costing, while bottom-up approaches encompass microcosting, the ingredients approach and patient-level costing. These methodologies are used to approach the target unit from opposite levels of aggregation and have significantly different data requirement.

1.1 The top-down approach

The top-down approach targets the unit of activity from the highest level of data aggregation. In its most rudimentary form, the top-down approach can, for example, be used to calculate the average cost per patient using the total expenditure and number of patients accessing a service. This effectively assumes that all patients cost the same amount. This may not be a major issue for services, such as GPs, in which costs may be driven by the number of visits rather than the intensity of care received by the different patients in a single visit. However, this assumption may be unsuitable for services in which there can be considerable variation in the resources used by different patients as part of a single episode of care such as an inpatient discharge. This could be problematic for the expenditure projections as the impact of changes to costs due to changes in patient characteristics would not be captured.

Variation in costs can, however, be captured using more nuanced top-down approaches. Generally, this involves the division of patients into groups and subgroups. While the creation of groups and subgroups introduces some variation in costs, it is important to note that the average unit cost estimated for each group is still an average, but of a somewhat more homogenous group of patients. In this way, an assumption is made that patients with some shared characteristics, beyond simply receiving the same health or social care, cost the same amount. The creation of each group or subgroup also increases the number of data points required.

1.2 The bottom-up approach

The bottom-up approach targets the unit of activity from the highest level of data disaggregation. At its most basic, the bottom-up approach attaches the appropriate cost to each of the component resources. These resources can include clinical staff time, non-clinical staff time, equipment and the use of land and buildings. Staff costs are often included in a unit cost by multiplying the annual salary of the relevant type of staff by the proportion of that staff member's annual work time used to treat the relevant patient. The cost of equipment and buildings, on the other hand, are often annuitized over their expected useful life or included as depreciation. Bottom-up approaches generally produce more precise unit costs than top-down approaches (4).

The precision gained by adding together the costs of each component of care makes the bottom-up approach very useful in capturing variations in costs when changes are being made to existing services (5). However, the price of this extra quality is the extra cost and time needed to gather the data and undertake the

necessary calculations (6). Overheads, which may include low cost items, such as utilities and non-clinical supplies, or indirect resources used by a patient, such as administration, support staff and some capital goods, are also captured using the bottom-up approach. It is common for overheads to be included as a percentage of staff costs in order to reduce the burden of using the bottom-up approach. This can be particularly advantageous in the case of a health care professional, such as a community based physiotherapist, who may work fairly independently and not as part of a larger cost centre. The availability of these overhead rates from a representative sample would reduce the data burden involved in using the bottom-up approach considerably.

1.3 Advantages and disadvantages of the two approaches

The bottom-up approach assigns costs to each input of a treatment service. In this way, the actual cost of treatments can be calculated. Costs calculated using the bottom-up approach are more precise than costs calculated by the top-down approach. This extra precision allows for the greater analysis of interpatient variations in cost. Similarly, the large number of individual observations of cost is more likely to allow for the statistical analysis of cost variation (7). This extra precision may be of particular use for health technology assessments, in which even small variations in cost inputs can have profound effects on the cost effectiveness of interventions (5). These benefits of the bottom-up approach do not, however, come without cost. The extra precision is dependent on a greater number of data points. The gathering of this extra data can be expensive in terms of both time and money. The method is also more complex. With so many data points to collect, the possibility of overlooking a cost input can increase. The allocation of overheads can also be particularly tricky (7).

The top-down approach is easier to perform than the bottom-up approach. It has fewer data requirements, and much of the data are routinely collected for accounts and management. As such, research using top-down approaches is less demanding in terms of time, knowledge and money. With fewer data points it is also less likely that inputs will be missed. On the other hand, the top-down approach does not allow for the analysis of interpatient variation and the secondary data may need to be validated (7).

2 Overview

The methods used to calculate unit costs in a health or social care setting by 44 different studies were investigated. The approaches used and costs included for different types of studies internationally and in Ireland are summarised in Table 1, as well as in Tables A1 and A2 in the Appendix. Of these studies, four were

projection models of health and social care, eight were conducted in an Irish setting and 32 were conducted outside of Ireland. Of the four projection models of health and social care, three used a top-down approach to estimate unit costs (8-10), while one used a combination of a bottom-up approach and a top-down approach (11).

Of the eight studies conducted in Ireland, one was a guideline for the conduct of economic evaluations of health technologies Ireland, six were disease/setting specific and one was a health technology assessment. The guideline was produced by the Health Information and Quality Authority (HIQA) and includes methodological guidance on the calculation of the costs of staff and capital goods for economic evaluations in health care in Ireland. The guideline suggested the use of a bottom-up approach to estimate the cost of staff and capital goods (12). Four of the disease/setting specific studies used a bottom-up approach to estimate unit costs (13-16), while one other disease/setting specific study used a mix of a bottom-up approach and a top-down approach (17) and another used a top-down approach (18). One Health Technology Assessment used a mix of a bottom-up approach and a top-down approach to estimate the unit cost of an intervention (19).

Of the 32 studies conducted outside of Ireland, 13 were non-disease specific, 13 were disease/setting specific and six were health technology assessments. Seven of the 13 non-disease specific studies used a bottom-up approach to estimate unit costs (2, 20-25), while four used a top-down approach (26-29) and two used a combination of a bottom-up approach and a top-down approach (30, 31). Eight of the 13 disease/setting specific studies used a bottom-up approach to estimate unit costs (32-39), while five used a mix of bottom-up approaches and top-down approaches (40-44). Four of the six health technology assessments used a bottom-up approach to estimate unit costs (45-48), while one used a top-down approach (49) and one other used a mix of a bottom-up approach and a top-down approach (50).

The majority of the Irish studies (62.5%), the international non-disease specific studies (54%), the international disease/setting specific studies (62%) and the international health technology assessments (67%) either proposed using or used a bottom-up approach to estimate unit costs. Only among projection models of health and social care was a top-down approach used most regularly (75%). It is perhaps unsurprising that the bottom-up approach was most favoured among health technology assessments as this is where the benefit of more precise estimates may be most acute. By contrast, it may be the case that the greater number of data points, and so research time and skill, involved in estimating the

bottom-up costs of a wide range of health and social care services may have been off-putting for those engaged in non-disease specific and projection modelling research. This disadvantage of the bottom-up approach may not have been as detrimental to those estimating unit costs in a single disease area.

Of the 44 studies, six referenced the Personal Social Services Research Unit (PSSRU) (2) as a source for some of their unit cost estimates or for some or all of their unit cost methodology (3, 17, 19, 45, 48, 50). The PSSRU have reported on the unit costs of care in the United Kingdom annually since 1992. Curtis and Burns published the most recent report in 2017 (2). The unit costs of many health and social services, both in the community and in hospital settings are calculated as part of this report.

In addition to the 44 studies investigated in this review of unit costing methods, 51 further studies sourced some or all unit cost estimates or unit cost estimate methodology from the PSSRU[1] (2). These studies have not been included in this review as they either sourced unit costs from the PSSRU and so did not estimate them, or used PSSRU methods that have been directly reviewed. For instance, Francois et al. (2008) (51) used PSSRU unit cost estimates for participants in the UK, eight other European countries, Canada and South Africa, while Chamberlain et al. (2011) (52) adapted PSSRU methods to the United States setting. The former may be problematic, as the pattern of resource use across disciplines may differ between countries. Indeed, these differences can be partly driven by differences in the relative costs of disciplines in these countries (53). As such, unit costs calculated in one jurisdiction may not be suitable for use in another. Of the 51 studies, three were projections of health and social care, three were non-disease specific studies, 17 were health technology assessments and 28 were disease/setting specific studies. The bulk of these studies took place in the UK.

Faraq et al. (2013) (54) is a systematic review of the unit costs of allied and community services used by older people in Australia. Of the studies set in Australia, it was found that the cost of private sector services can be as much as double that of public sector services, though this does vary somewhat across disciplines. Variation was also observed in the unit costs of care in different countries. This may be attributable to differences in the societal value attached to services in different countries (54). The authors reported that many of the international studies included in the review were economic evaluations from the United Kingdom and that most of these had used PSSRU estimates (54).

[1] See footnote 6 for full list of studies that used unit cost estimates or unit cost estimate methodology from the PSSRU.

Further research into methods to calculate unit costs is currently underway in Europe. The Programme in costing, resource use measurement and outcome valuation for use in multi-sectoral national and international health economic evaluations (PECUNIA) project began in January 2018 and will run until December 2020. Researchers from ten universities and institutes across six countries will contribute to the project. The aims of the project are to develop standardised, harmonised and validated methods for the assessment of costs and outcomes of healthcare interventions within and across European countries. This is primarily targeted at improving the comparability of cost-effectiveness studies across countries (55).

Table 1: Summary of approaches used and costs included by study type.

Study Type Study Type	Approach				Percentage of Studies Including:				
	Bottom-up	Mixed	Top-down	Total	Capital	Staff	Materials	Direct	Indirect
Projection Models	0	1	3	4	50	50	50	50	25
Irish									
Disease/Setting Specific	4	1	1	6	33	100	83	100	50
Health Technology Assessment	0	1	0	1	100	100	100	100	100
Guideline	1	0	0	1	100	100	100	100	100
Total (Irish)	5	2	1	8	-	-	-	-	-
International									
Non-Disease Specific	7	2	4	13	70	85	85	85	77
Disease/Setting Specific	8	5	0	13	62	100	85	92	62
Health Technology Assessment	4	1	1	6	33	83	66	83	83
Total (International)	19	8	5	32	-	-	-	-	-

3 Projection Models

Wanless (2002) (8) projected the future trends in health, health care resource use and expenditure in the UK. A top-down approach with subgroups was used to estimate unit costs. For example, patients admitted with heart disease were grouped by sex, decedent/survivor status and age. Each group contained patients of the same sex, decedent/survivor status and age cohort. In total, patients were sorted into 84 separate groups, though only 42 groups were used to estimate unit costs as patients were not separated by sex for this estimation. So, each of 42 estimated unit costs were attached to two groups of patients, a male group and a female group of the same age cohort and decedent/survivor status. The cost per patient was calculated by dividing the total cost of inpatient admissions for heart disease by the number of patients that were admitted.

The overall cost per patient was then multiplied by the number of patients in each of the 42 groups to estimate the total cost of each group. The average cost of each group was divided by the average length of stay of each group to estimate the average unit cost of each day of treatment for inpatients with heart disease disaggregated by age and decedent/survivor status. The unit costs for each group were potentially more accurate than the overall average cost that could be estimated in a rudimentary fashion. These estimates were still averages, albeit of smaller more homogenous groups. Various assumptions were made to calculate these average unit costs. These were that costs are spread evenly over the entire length of stay, that costs did not differ between males and females and that the severity of the disease neither altered cost nor was altered by age.

Harris et al. (2008) (9) is a USA based study which evaluated the Veterans Affairs (VA) enrolee health care projection model. The enrolment level, utilization rate and unit cost were multiplied together to calculate expenditure for each of 58 medical services. An average unit cost was obtained for each health service category by age, sex and market. For some health service categories, such as outpatient mental health programs, special VA programs and prosthetics, the VA's Decision Support System (DSS) contains unit costs that can be input into the projection model. These are bottom-up unit costs. For the majority of health service categories, such as inpatient, ambulatory and prescription charges, VA unit costs are estimated based on Medicare allowable charges or community billed charges. These are top-down unit costs.

To derive a VA unit cost from Medicare allowable charges, the first step is to take the national average Medicare charge. The average Medicare charge is adjusted to reflect regional differences in unit costs due to cost of living and treatment intensity. For a few health service categories a further adjustment to reflect

covered benefit is also made. Each of these steps is taken twice; once for a Well Managed estimate and again for a Loosely Managed estimate. Well Managed and Loosely Managed refer to the efficiency of clinical management of different health plans. These two estimates are combined using the Degree of Community Management (DoCM) percentage. For example if the DoCM percentage is 22 per cent, then the combined estimate would be the summation of 22 per cent of the Well Managed estimate and 78 per cent of the Loosely Managed estimate. The combined estimate is then adjusted for age and gender to give the base unit cost.

Wittenberg et al. (2008) (11) projected the demand for social care for older people in England from 2005 to 2041. The authors derived all of the relevant unit costs from Personal Social Services (PSS) expenditure (EX1)[2] data. The average unit cost of each social care service was calculated by dividing the gross expenditure of each social care service by the number of recipients of each service.

Leung et al. (2007) (10) projected Hong Kong's health spending to 2033. Activity level data, derived from the Thematic Household Survey 2002, were obtained from the Hospital Authority and Department of Health. Unit costs were obtained from Hong Kong's domestic health accounts (57). It appears that the costs of each health care sector were calculated using a top-down approach[3]. The average unit cost of each health care sector was then calculated by dividing the total expenditure of each health care sector by the level of activity in each sector.

4 The Irish unit cost literature[4]

HIQA (2018) (12) includes methodological guidance on the calculation of the costs of staff and capital goods for economic evaluations in health care in Ireland. It is recommended that yearly depreciation of buildings, modular buildings, computers and ICT systems, other equipment and motor vehicles is included in the cost of care until the good is either disposed of or fully depreciated. The rate of depreciation ranges from 2.5 per cent per annum to 33.33 per cent per annum in a straight line basis, depending on the type of good. The report also notes that the cost of equipment maintenance should be included each year. For labour costs, the report proposes that the midpoint of the Department of Health's consolidated salary scales for public sector employees should be used. The midpoint salary should then be supplemented with superannuation of 4 per cent of direct salary costs, the

2 PSS EX1 was completed annually by 150 councils that had Social Services Responsibilities in the UK (56).

3 No detail is provided as to how the unit costs were calculated. However, the domestic health accounts only provide expenditure at the sectoral level.

4 Tilson et al. (2007) (58) undertook a cost-effectiveness analysis of hepatitis B vaccination strategies in Ireland. However, supplementary data containing information on the methodology and sources used to calculate unit costs were not available.

employer's contribution to PRSI and overheads as set out in the revised Regulatory Impact analysis guidelines (59). It is advised that overheads should be included at a rate of 25 per cent of direct salary costs if no more specific data are available.

Connolly et al. (2015) (15) conducted a study to calculate the resource use and cost of patients with amyotrophic lateral sclerosis (ALS). There was one multidisciplinary clinic in Ireland, to which each ALS patient had access. To gather the resource use data necessary to use the bottom-up approach, a retrospective review of 119 charts as well as 17 telephone surveys of primary care givers were undertaken. Numerous sources were used to estimate the appropriate cost associated with each resource used. These sources included Department of Health salary scales, Health Service Executive (HSE) for outpatient attendances and accident and emergency admissions, Healthcare Pricing Office (HPO) Hospital In-Patient Enquiry (HIPE) scheme[1] for inpatient discharges, the Primary Care Reimbursement Service (PCRS) and the MIMS Ireland catalogue for medications and the Irish Motor Neuron Disease Association for aids and appliances. The unit cost of treating patients with ALS was estimated by multiplying the unit cost of each resource used by the number of resources used.

Gillespie et al. (2011) (14) examined the cost of gestational diabetes mellitus (GDM) in Ireland. The authors used a bottom-up approach. The costs of screening, testing and treatment of GDM were calculated. Staff time, consultations, equipment and medication were incorporated into the unit costs. Data on resource use were sourced within Ireland where possible and from the United Kingdom where it was not. Administration and the oral glucose tolerance test resource use were collected within the study. The number of diabetic specialist nurse consultations, dietician consultations as well as the number of lancets, testing strips and blood glucose meters were assumed. The dose of medications were obtained from the National Institute of Clinical Excellence. Consultants provided information as to the resource usage of women with and without GDM.

Data on the costs of the resources used were sourced within Ireland where possible and from the United Kingdom where it was not. Administration costs were obtained from a telecommunications provider and a job advertiser. The costs associated with the oral glucose tolerance test was sourced from ATLANTIC Diabetes in Pregnancy and the Department of Health and Children. The cost of consultations was also supplied by the Department of Health and Children. The cost of medication was taken from the MIMS Ireland catalogue. The costs of delivery and neonatal care were sourced from the Department of Health and Children. The unit cost of detecting and treating GDM was estimated by applying the unit cost of each resource used by the relevant women.

O'Sullivan et al. (2016) (18) conducted an analysis of the costs of implementing advanced care planning for nursing home residents using a top-down approach. This analysis was conducted on the back of a clinical trial. The probability of residents in three nursing homes being admitted as a hospital inpatient before and after the intervention 'Let Me Decide' was implemented. It was assumed that residents would be transferred by ambulance. The costs associated with an inpatient stay for different DRGs was sourced from the 2013 version of the ready reckoner. These were used to form an average cost per episode. The cost associated with an ambulance transfer, sourced from Gannon et al. (2007) (60), was then added to the average cost of hospitalisation to calculate the unit cost of hospital admission from a nursing home. The change in the probability of a hospital admission and the average cost per case obtained from the three nursing homes were then applied to the population of nursing home residents in Ireland. This implies that the three nursing homes were a representative sample of all nursing homes in Ireland.

Hanly et al. (2015) (13) estimated the direct costs of radiotherapy for rectal cancer using a bottom-up approach. Resource use was obtained through interviews with management and clinical staff and onsite observation of treatments. The purchase price of equipment was obtained either from two hospitals or from Kesteloot et al. (2000) (61).The cost of repair and maintenance of equipment was obtained from the hospitals. Resources were categorized into the cost of labour, capital, consumables and overheads. The costs of labour and overheads were calculated in accordance with guidelines set out in HIQA (2014) (62), while building costs were not included in the analysis. Capital costs were annuitized over their expected life and equipment was assumed to have a discount rate of 4 per cent. The cost of equipment was assigned to patients on a per minute basis. The unit cost of radiotherapy for patients with rectal cancer was then estimated by multiplying the unit cost of each resource by the number of each resources utilised.

Butler et al. (2016) (16) examined the cost of frailty in people with cognitive impairment. The study calculated formal health and social care costs and informal caregiving costs using a bottom-up approach. Formal health and social care activity included, but was not limited, to inpatient visits, accident and emergency visits, outpatient consultations and general practice visits. Resource use was collected over a six-month period. The unit costs of resources were obtained from Irish data sources including the HPO HIPE scheme and salary scales from the Department of Health and Children. Informal caregiving activity included hours dedicated to activities of daily living and supervision. For employed caregivers, the cost was one hour of the average industrial wage, while for unemployed caregivers, the cost was

25 per cent of the average industrial wage. The unit cost of health and formal care was estimated by multiplying resource use by the unit cost of each resource, before summing the resultant costs per resource. The unit cost of informal care was estimated by multiplying hours of informal care by the appropriate cost per hour.

Manca et al. (2003) (19) undertook a cost-utility analysis of tension free vaginal tape versus colposuspension across 14 centres, 13 in the United Kingdom and one, the National Maternity Hospital, in Ireland. The analysis was part of a trial, during which resource use was recorded. Estimates of the unit cost of the resources used were gathered from United Kingdom sources. These included the Personal Social Services Research Unit (PSSRU), review bodies for nurses and doctors, the Chartered Institute of Public Finance and Accountancy and Sculpher (1996) (63). The unit costs were estimated using a mixture of the bottom-up and top-down approaches. For instance, the unit cost of staff was calculated using a bottom-up approach by applying overheads to the midpoint on the relevant salary scale. The unit cost of staying on a ward, on the other hand, was calculated using a top-down approach by adding the average hospital ward and general service cost per inpatient day estimated by a hospital. The unit cost of outpatient care was assumed to be the same as the cost of staying on a ward. The unit cost of each arm of the model was then estimated by multiplying unit cost of each resource by the number of each resource used by each arm of the model.

Brick et al. (2015) (17) performed an economic evaluation of palliative care in Ireland using a bottom-up approach where possible and a top-down approach otherwise. Resource use data were obtained from HIPE and other decedent healthcare records, key informants and nurse time-use diaries from community specialist palliative care teams. A wide range of Irish sources were used to gather cost data. These sources included the HSE, the PCRS, the Central Statistics Office, the National Consumer Agency and the Irish Cancer Society. The unit costs of allied health staff were calculated, using a bottom-up approach, by adapting the PSSRU method to the Irish setting. Two unit costs were calculated for GPs using a top-down approach, one for medical cardholders and another for non-medical cardholders. For medical cardholders, the average payment to GPs per medical cardholder was divided by the average number of GP visits per medical cardholder, while, the average cost of a GP visit for a non-medical cardholder was obtained via an independent price survey. The unit costs of dentists, formal community care, hospital costs, day care, nursing homes, hospice, prescription drugs, meals-on-wheels, equipment, home modifications and informal care were also calculated. The unit costs for formal and informal care per patient in the last year of life was estimated by multiplying the unit cost of resources by the patient's utilisation of said resources.

5 The International unit cost literature

5.1 Non-disease specific

Curtis and Burns (2017) (2) is the most recent in a series of annual reports on the unit costs of care in the United Kingdom, that has been published by the PSSRU since 1992. The unit costs of many health and social services, both in the community and in hospital settings are calculated in this report. The unit costs and the methods used to estimate them are extensively cited in the literature[5], particularly in the United Kingdom. The framework used by the PSSRU to calculate the unit costs of staff differs somewhat from the framework used to calculate the unit costs of services. The framework used to calculate the unit costs of a community based occupational therapist and the framework used to calculate the unit cost of a place in a Care home for people requiring long-term mental health support will be used to exemplify this point.

For an Occupational therapist, the starting point for the bottom-up calculation of the unit cost of health care staff begins with the mean full time salary. The employer's national insurance contribution and the employer's contribution towards superannuation of 17 per cent of the basic salary are added. This is the direct care salary. The qualification costs associated with an Occupational therapist are then added. The qualification costs are a function of the costs of tuition, infrastructure, clinical placement, lost productivity during training and the expected working life of the profession. After this, three forms of overheads are added:

1) Direct overheads, amounting to 29 per cent of the direct care salary, cover management, administration and utilities.
2) Indirect overheads, calculated as 16 per cent of the direct care salary, cover general management and support services. These overheads are based on the accounts of ten community trusts[6].
3) Capital overheads, including building facilities are annuitized over 60 years with a 3.5 per cent discount rate.

A location multiplier is then applied to the total yearly cost to account for differences in cost inside and outside of London. The total yearly cost is divided by time worked per year to give the unit cost per period of time of an Occupational therapist.

5 Studies that used PSSRU calculations or methods for some or all unit costs (3, 17, 19, 45, 48, 50-53, 64-111)

6 Community trusts are the bodies that deliver community care in the UK.

For a place in a Care home for people requiring long-term mental health support, the starting point of the unit cost estimate is the cost of buildings. Capital costs are annuitized over 60 years, with a 3.5 per cent discount rate for the first 30 years and a 3 per cent discount rate for the second 30 years. To this, the median weekly cost estimate of the Adult Social Care Finance Return for adults aged 18-64 who are in need of long-term mental health support, is added. Finally, a personal allowance, as calculated by the Department of Work and Pensions, is added. The method of calculating this unit cost more closely resembles a top-down approach than does the PSSRU unit cost methodology for staff seen above.

Riewpaiboon et al. (2011) (22) is a cost analysis of the reimbursement of pharmaceutical services in hospitals in Thailand. Costs were calculated using a bottom-up approach. The cost of construction, buildings, furniture, equipment and vehicles were included as capital costs with a discount rate of 3 per cent. The useful lifespan of equipment and buildings were five and 25 years respectively. Staff costs included salaries, administrative payments and overtime. Overheads, at a rate of 20 per cent of the direct pharmacy costs, were included to represent the cost of capital, staff and materials from supporting staff. Unit costs were calculated using a bottom-up approach by applying the cost of pharmaceutical items to the pharmaceutical use of patients. The unit costs of different hospital settings were calculated by tracking the resource use of patients and multiplying the amount of each resource used by the unit cost of said resource. As such, there are separate unit costs for regional hospitals, general hospitals, ambulatory settings, inpatient settings, specific pharmaceuticals and each combination thereof.

Younis et al. (2010) (25) studied the determinants of hospital costs in Palestine. Capital and staff costs were calculated using a bottom-up approach for each hospital department. The cost of drugs, laboratories and consumables were assigned to each department based on their actual distribution. Other overheads were assigned to departments, using a top-down approach, based on the relative weight of their direct costs. The average unit cost of each department was estimated by dividing the total expenditure of each department by the number of admissions to that department.

Younis et al. (2013) (24) estimated the cost of public hospitals and primary health care centres in Palestine. All operational costs were assigned to individual departments in hospitals and primary health care centres. Operational costs included the cost of staff, pharmaceuticals and supplies. Capital costs were not included in the analysis. Each department was categorised as being an overhead, intermediary or final department. The costs of overhead departments were allocated to intermediary and final departments using the step down allocation

method. The average unit cost of each intermediary and final department was then estimated by dividing the total departmental expenditure by the number of patient visits to that department.

Ylijoki-Sørensen et al. (2014) (23) studied the costs associated with cause of death investigations in Finland and Denmark. The costs were calculated using a bottom-up approach. This study produced unit costs for both forensic and medical autopsies in Finland and Denmark. The cost of medical autopsies included the costs of staff, buildings, equipment, morgue costs and the transport of cadavers in both jurisdictions. The cost of forensic autopsies included these same costs as well as the costs of additional investigations, forensic chemistry and trainee forensic examiners. The cost of forensic examiners was also included in Denmark but not in Finland. In all cases, the average unit cost was calculated by dividing the total expenditure on autopsies in each country by the number of autopsies in each country.

Hariharan (2015) (26) estimated the cost involved in the running of four operating rooms in a hospital in the West Indies per day. A top-down cost block approach was used to calculate the costs involved in running the operating rooms. This method involved categorising the costs into six baskets. These were: capital costs, estate costs, the cost of nonclinical support services, the cost of clinical support services, the cost of consumables and staff costs. Capital costs mainly included the costs of various items of medical equipment, depreciated at a rate of 10 per cent since purchase. Estate costs included the costs of utilities, sterilization services, laundry and ventilation. The costs of nonclinical support services were made up of salaries for non-medical staff. The costs of clinical support staff comprised the costs of medical staff with the exception of consultants, surgeons and anaesthetists. The cost of consumables included the costs of disposable and single use equipment and anaesthetics. Finally, staff costs were made up of the salaries of consultants, surgeons and anaesthetists. The average unit cost of running four operating rooms was calculated by dividing the annual costs associated with running the four operating rooms by the number of days in the year. This was then divided by the number of operating rooms (four) to give the average unit cost per day associated with running an operating room.

Javid et al. (2016) (30) compared activity-based costing with traditional cost systems for calculating the unit costs of medical services in a hospital in Iran. To use the activity based costing method, the hospital was split into patient care cost centres and supportive cost centres. The direct cost of each cost centre was calculated, using a bottom-up approach, by summing all of the capital, staff and material costs associated with each cost centre. Where staff worked in more than

one cost centre, their cost was apportioned according to their workload in the different centres. Capital costs included the straight line discounted depreciation of buildings, vehicles, equipment and furniture. The direct costs associated with supportive cost centres were allocated to patient care cost centres according to resource cost drivers.

These cost drivers were: personnel workload, quantity of equipment, floor area, and estimation. The costs associated with each patient care cost centre was then apportioned to specific activities, using a top-down approach. Resource use for each activity was determined through structured interviews with the involved people[7]. The average unit cost per bed day was calculated by summing the cost of each activity and dividing by the number of patients availing of each activity. For a number of medical services, the estimated unit costs were lower when calculated by the traditional cost system as compared to activity-based costing. This difference was statistically significant at the 99 per cent level of significance for laboratory services, ophthalmology services, pharmacy services and surgical unit services. The total unit cost was also lower when calculated by the traditional cost system rather than activity based costing.

Mann (1999) (28) estimated the unit cost of consumables in an intensive care unit in New Zealand. The annual fixed cost of consumables that could not ordinarily be assigned individually, such as stationary, disposable cups and hand towels, were combined. The average unit cost of consumables per patient hour was estimate by dividing the total annual cost of consumables by the annual number of patient hours in the intensive care unit.

Mark et al. (2009) (20) investigated the relationship between nursing working conditions and nursing unit costs. The analysis was conducted across 210 nursing units in the USA and used a bottom-up approach. The cost of nursing incorporated the cost of salaries, fringe benefits and overtime of registered nurses, licensed practical nurses, unlicensed personnel permanently assigned to a unit and supplemental nurses on a unit over a six-month period. The analysis did not include fixed costs, supply costs nor capital costs. The salaries were adjusted for regional variation using the Centers for Medicare and Medicaid Services (CMMS) wage index. The average unit cost of nursing per patient day was estimated by dividing the total salary costs by the number of patient days reported in the same nursing units over the same six-month period.

[7] It is unclear whether the involved people were members of staff, patients or both.

Minh et al. (2010) (29) estimated the cost of clinical services in rural district hospitals in Vietnam using a top-down approach. Capital costs, operating costs and staff costs were included in this analysis. Capital costs included straight line depreciation of buildings, vehicles and equipment. Operational costs included utilities, travel expenses, training, maintenance and non-clinical supplies. Each of these costs was included in the cost of each hospital department. The departments were then organised into direct cost centres and indirect cost centres. Direct cost centres provided services directly to patients while indirect cost centres supplied services to other cost centres. The costs of indirect cost centres were allocated to direct cost centres using the step down approach, until all costs were part of cost centres delivering services directly to patients. Costs were allocated from indirect cost centres to direct cost centres using four cost drivers; floor space of direct cost centres, direct costs of final cost centres, the costs of staff associated with direct cost centres and the number of bed days associated with direct cost centres. The average unit cost was then estimated by dividing the total cost of each direct cost centre by a relevant form of patient interaction, such as visits or bed days.

Oostenbrink et al. (2003) (21) estimated the cost of inpatient hospital days in the Netherlands. Capital costs, staff costs, the cost of consumables and overheads were all included in the analysis. Nursing costs included wages, fees for irregular hours, social premiums and the cost of replacement during illness. The average unit cost of nursing per inpatient day was estimated by dividing annual nursing department costs by the number of inpatient bed days. The average unit costs of specialists and residents who were directly employed by the hospital were calculated in the same manner. Self-employed specialists and residents provided an estimate of the amount of time per day spent with a single inpatient. This time estimate was multiplied by the average salary of specialists and residents to calculate an annual unit cost. Indirect costs, such as equipment and overheads, were allocated to final cost centres based on weightings of relevant cost drivers such as amount of floor space, number of bed days or number of full time equivalents. The average unit cost of these indirect costs was then estimated by dividing indirect costs in each final cost centre by the number of inpatient days in each final cost centre. The average unit cost of each final cost centre was then estimated by summing these component unit costs.

Ramiarina et al. (2007) (31) estimated hospital costs as a function of patient and admission characteristics in Brazil. All of the hospital's costs were assigned to one of three centres: the auxiliary diagnostic and treatment centre, the support and administration centre or the expense generator centre. The expense generator centre contained costs directly related to ambulatory care, clinics and surgery. The cost of maintenance, management and transport are a few examples of the costs

included in the support and administration centre. The auxiliary diagnostic and treatment centre included all imaging costs, the cost of laboratories and the cost of blood banks. The costs associated with the support and administration centre and the auxiliary diagnostic and treatment centre were allocated to services in the expenses generator centre according to a weighting based on the number of patients per day in each service in the expenses generator centre. The average unit cost per patient day was estimated by dividing the total expenditure associated with each service in the expenses generator centre by the number of patient days in each centre. The average inpatient unit cost was then calculated by multiplying the average unit cost of a patient day in the relevant service by the length of stay of each patient.

Chatterjee et al. (2013) (27) estimated the unit costs of different medical services in India. The costs were estimated using a top-down approach. Hospital departments were divided into two categories – departments that directly provided care to patients, i.e., patient care cost centres, and departments that supplied direct support to patient care cost centres, i.e., supportive cost centres. Patient care cost centres included the outpatient department, the inpatient department and the operating theatre, while supportive cost centres included the administration department, the laundry department, the kitchen and the transport department. The direct costs of each cost centre were calculated by summing the cost of staff, capital costs and the cost of materials. Capital costs included the annualised discounted depreciation of building, vehicles, equipment, and furniture and the opportunity cost of land. The useful life of buildings and structure was considered 20 years, while the useful life of other capital items was assumed five years. A 3 percent discount rate was applied to all capital costs. Staff costs included salaries and fringe benefits. Where staff worked in more than one cost centre, the cost associated with that member of staff was allocated to each cost centre according to the proportion of time spent working in each cost centre.

The costs of supportive cost centres were allocated to patient care cost centres using the simultaneous equation method. These costs were allocated according to cost drivers of patient care cost centres, such as floor area or staff full time equivalents. These were then known as the indirect costs of patient care cost centres. The full cost of each patient care cost centre was estimated by summing all relevant direct and indirect costs. The average unit cost of each patient cost centre was estimated by dividing the total cost of each patient cost centre by a relevant output, such as patient visits or patient bed days.

5.2 Disease/Setting specific

Beck et al. (1999) (32) compared the cost of paediatric HIV hospital provision as estimated by hospital prices with estimates obtained through a research based costing exercise in the UK. Unit costs for outpatient visits, inpatient days, tests, procedures and pharmaceuticals were estimated using a bottom-up approach. The cost of outpatient visits and inpatient days included the costs of staff time allocated to HIV related duties, overheads that incorporated other general staff, miscellaneous expenditure, overheads and central support services. The cost of tests included the sum of money transferred between departments in hospitals as well as additional department costs and overheads, central support services costs and the cost of infection control. The cost of surgical procedures included the cost per operating hour and overheads combined with the duration of typical procedures. Pharmaceutical costs included the price of all drugs used by children with HIV combined with the average daily dose of each medication. The average unit cost of inpatients, outpatients, tests, surgeries and medications were calculated by dividing the relevant total expenditure by the number of inpatient days, outpatient visits, tests performed, surgical procedures performed or the number of doses of pharmaceuticals taken.

Zulu et al. (2017) (39) studied cost and utilisation patterns of a pilot sign language interpreter service in the primary care setting in a number of regions of South Africa. Costs were calculated using a bottom-up approach. Capital and recurring costs were recorded as part of the project. The cost of training an interpreter, office space, furniture and equipment were included as capital costs. Furniture and equipment were assumed to have a useful lifespan of 10 and five years respectively. Staff costs, utilities, consumables and transport were included as recurrent costs. Overheads included the cost of the proportion of buildings used for project purposes. The average unit cost was calculated by dividing total expenditure by the number of people who used an interpreter. As such, the unit costs reflect an average cost across different ages, genders and regions in South Africa.

Groessl et al. (2009) (35) conducted a cost analysis of physical activity intervention for older people in the USA. The cost of the intervention was calculated using a bottom-up approach. The number of intervention sessions per group of participants as well as the amount of time needed for each staff member to provide a session were recorded. Similarly, the number of participants in each group and their attendance at sessions were recorded. Facilities and indirect costs were included as a percentage of health care staff costs. Expenditure on exercise equipment and all other materials used as part of the intervention was also recorded. The total cost of the intervention was then divided by the number of

intervention participants to estimate the average unit cost of the intervention per participant. So, although the cost of the intervention was calculated using a bottom-up approach, the unit cost was derived on average. This does not affect the precision of the unit cost estimate with respect to the entire intervention group. However, it does make it impossible to distinguish between the unit cost of different subgroups of the participants.

Tianviwat et al. (2009) (43) estimated the unit cost of dental services in institutional and community settings in Thailand. The costs were estimated using a mix of the bottom-up and top-down approaches. Hospital departments were divided into two categories – departments that directly provided dental care to patients, i.e., service cost centres, and departments that supplied direct support to service cost centres, i.e., supporting cost centres. Service cost centres consisted of the outpatient department, the emergency department, the dental department, the primary care unit, the Thai traditional medicine department, and the inpatient department. While supporting cost centres consisted of administration, supplies, registration, nursing, pharmacy, laboratory, x-ray, and delivery room. The costs of capital depreciation, materials and staff were included in the costs of each cost centre using a bottom-up approach.

The cost associated with supporting cost centres were allocated to service cost centres, using a top-down approach, according to weightings of key cost drivers, such as the proportion of administration time devoted to dental activities or the number of autoclaves provided to the dental unit. Direct and indirect costs associated with dental service cost centres were then apportioned to specific dental activities. These costs were assigned based on interviews with dentists and dental nurses. The cost of staff was allocated to these dental activities according to the time requirements of each activity. The cost of materials were allocated to activities according to the number of units required for the activities. The average unit cost was then estimated by dividing the total cost of each activity by the number of patients that used said activity.

Wanitphakdeedecha et al. (2010) (38) estimated the unit cost of a Mohs[8] and Dermasurgery unit in Texas, USA. The costs were calculated using a bottom-up approach. Direct and indirect costs contributed to the total cost of the unit. Direct costs consisted of capital costs, staff costs and the cost of materials. The cost of staff was the single largest driver of costs. The average amount of time spent at the unit and the amount of time spent on each procedure by surgeons was obtained through interviews with the surgeons. The annual cost of Mohs surgeons

8 A type of microscopically controlled surgery

was estimated by multiplying estimated time working in the unit by the average income of a surgeon. It was assumed that nursing and support staff worked at the unit for the same proportion of the year as the surgeons. As such, the costs of nurses and support staff were estimated in a similar manner as the mohs surgeons. Indirect costs include overheads and administration costs. The average unit cost of each service and medical procedure was estimated by dividing the cost of each service or procedure by the number of services or procedures.

Chatterjee et al. (2011) (41) examined the economic burden of diabetes in Thailand. As part of this study, the authors estimated the unit cost of medical services at Waritchaphum hospital. The costs were calculated using a mix of the bottom-up and top-down approaches. Each of the departments in the hospital was classified as either a patient care cost centre or a supporting cost centre. The direct costs of each cost centre were calculated, using a bottom-up approach, by summing the costs of capital, staff and materials with which it was associated. The direct costs of the supporting cost centres were than allocated to the patient care cost centres, using a top-down approach, using the simultaneous equation approach. The average unit cost of inpatient stay per day, outpatient per visit and pharmacy per prescription was estimated by dividing the total cost of each cost centre by the relevant unit of activity, i.e., bed day, visit or prescription.

Chou et al. (2007) (33) studied the costs associated with adverse event procedures for an International clinical trial. Costs were calculated using a bottom-up approach. The costs included the cost of personnel, pharmacy costs, the cost of patient care, laboratory costs and the cost of equipment. Time and motion studies and interviews with staff were used to estimate the proportion of staff time dedicated to adverse event procedures. For the cost of personnel, this proportion was multiplied by annual salary to estimate the cost of staff. The patient care costs associated with adverse events were estimated as a proportion of total patient care costs, using the same proportion as the proportion of unscheduled visits compared to all study visits. Laboratory costs were captured as contractual fees. Pharmacy costs reflect actual expenses billed to the study. The costs of equipment were apportioned according to the proportion of personnel time spent on adverse events. The average unit cost per adverse event was calculated by dividing the total expenditure associated with adverse events by the number of adverse events.

Dalaba et al. (2013) (42) examined the cost of maternity services in the primary care setting in Ghana. A mix of the bottom-up and top-down approaches was used to calculate the costs. Departments were categorised into three cost centres. These were the direct cost centre, the intermediary cost centre and the indirect cost centre. The direct cost centre included costs directly associated with antenatal

care, delivery care and family planning. The intermediary cost centre included the costs of diagnostic and departmental support. The indirect cost centre included the costs of services that were provided only to other departments and not patients. Recurrent costs – consisting of personnel costs, administrative costs, pharmacy costs, laboratory costs and the cost of medical supplies – were assigned as appropriate to each cost centre using a bottom-up approach. Personnel costs included overtime, housing allowances and training costs. Administrative costs included utilities, maintenance costs and transport costs.

Capital costs – consisting of the cost of buildings, the cost of vehicles and the cost of equipment – were also included for relevant cost centres. A discount rate of 3 per cent was applied to all capital costs. The cost of equipment was annuitized over a 10-year useful lifespan, while the cost of buildings was annuitized over a 30-year useful lifespan. All costs from the intermediary cost centre and the indirect cost centre were allocated to the direct cost centre, using a top-down approach. Finally, the average unit cost of each cost centre was estimated by dividing the total cost of each cost centre by the relevant output of each cost centre.

Davies et al. (2011) (40) studied the effects of pre-clinical group education sessions and system redesign on pain medicine units and patient outcomes in Australia. The average unit cost of the pain management unit per new patient was estimated by dividing the total salary costs of staff by the number of new patients offered an appointment. Capital expenses, the costs of goods and services, and the cost of office and clinic space were excluded from the analysis.

Demarré et al. (2015) (34) evaluated the cost of pressure ulcer prevention and treatment in nursing homes and hospitals in Belgium. The costs were calculated using a bottom-up approach. The cost of pressure ulcer prevention consists of the material cost per day and the labour cost per day for each patient. The material cost per day consists of the sum of all of the unit costs of materials used by each patient, while the labour cost per day is made up of the nursing labour cost per activity multiplied by the frequency of the activity per day. The unit cost of the prevention of pressure ulcers per patient per day was estimated by adding the unit cost per day per patient of pressure ulcer preventing devices and the unit cost of labour to provide prevention of pressure ulcers per day. The average unit cost of prevention per patient was then estimated by summing each patient's unit cost and dividing by the number of patients. The unit cost of the treatment of pressure ulcers in Belgium was calculated in a similar manner.

Villarreal Ríos et al. (2006) (44) examined the cost of caring for a diabetic patient with hypertension in the primary care setting in Mexico. Total costs were divided into fixed costs and variable costs. For variable unit costs, a group of experts advised the authors as to the types and amounts of activities that should be included. The amount of resources required for these activities was multiplied by the unit cost of each resource. The costs of the resources of all activities were added together to estimate, using a bottom-up approach, the variable unit cost.

For fixed costs, departments were classified as either intermediary departments or final departments. The cost of equipment, the cost of consumables, the cost of staff and the cost of capital were included in both types of departments, using a bottom-up approach. The costs associated with the intermediary departments were allocated to final departments, using a top-down approach, in proportion to the weighting of the final departments with respect to cost drivers. For instance, the final department that needs the most floor space might receive the highest proportion of furniture costs from intermediary departments. The fixed unit cost was estimated, using a top-down approach, when all of the costs associated with intermediary departments had been reallocated to final departments. The unit cost by reason of care was estimated by summing the fixed and variable unit costs.

Kamolratanakul et al. (2002) (36) examined the cost different types of tuberculosis patient at tuberculosis centres in Thailand. The costs were estimated using a mix of bottom-up and top-down approaches. Five cost centres were identified. These were treatment units, radiology units, laboratory units, pharmaceutical units and administration and support units. The direct costs of each unit were calculated, using a bottom-up approach, by summing the cost of staff, materials and capital for each unit. The costs of the administration and support unit were then allocated to the four other cost centres, using a top-down approach, using the simultaneous equation method, modified by appropriate criteria. The unit cost of each of the four other cost centres was then calculated by dividing the total cost of each cost centre by an appropriate output.

Kim et al. (2015) (37) studied the cost of adult voluntary male circumcision. The costs were calculated using a bottom-up approach. Costs were divided into direct costs and indirect costs. Direct costs consisted of the cost of consumables, the cost of non-consumables, the cost of training, the cost of staff and the cost of waste management. The costs of consumables per circumcision were taken from invoices of ordered equipment. The duration of the procedure was applied to the salaries of relevant health care workers to calculate the staff costs per circumcision. The cost of five days training for two professional nurses and two enrolled nurses was included. The amount of biohazardous waste per procedure was used to estimate

the cost of waste. Indirect costs, such as capital costs, maintenance and utility costs, the cost of support personnel, and the cost of management were also included. The unit cost per circumcision was estimated by multiplying the amount of each resource used by the cost of each resource.

5.3 Health Technology Assessments

Jones and Nickerson (1986) (49) examined the costs of the Early and Periodic Screening, Diagnosis, and Treatment program in Maine in the USA. Thirteen community based agencies contacted and enrolled children of families that were new and re-eligible for Medicare. The sum of the number of families informed, the number of children due for screening and the number of children for whom screening had been requested was defined as each agency's workload. Due to poor record keeping on the part of the agencies, the exact costs of informing families about the program could not be isolated. Therefore, the total amount billed to the state by each agency was taken as the cost. The state wide unit cost was estimated using a top-down approach, by dividing the total cost of all agencies by the combined workload of all agencies workload. This unit cost was multiplied by the total number of families to give the total cost of informing. The total cost of informing was divided by the total number of families, less those who were transferred or who lost their Medicare eligibility to estimate the unit cost of informing new or re-eligible families.

Graziosi et al. (2005) (47) conducted an economic evaluation of misoprostol in the treatment of early pregnancy failure compared to curettage after an expectant management. The costs were calculated using a bottom-up approach. Resource use by each patient was recorded. Resources used included visits to the outpatient clinic, number of ultrasound scans, misoprostol usage, need for curettage, days of day care, days of hospital admittance, visits to general practitioner or midwives related to early pregnancy failure, and the treatment of complications. The unit costs of staff, materials, equipment, housing and overheads associated with each used resource were calculated. The unit cost of treatment for each patient was estimated by multiplying the number of each resource used by the unit cost of each resource.

Brown et al. (2002) (46) conducted a cost effectiveness analysis of an antiplatelet drug (eptifibatide) in acute coronary syndromes. The cost of three procedures were estimated as part of this analysis, though not every study participant underwent a procedure. These procedures were a coronary arteriogram, a percutaneous coronary intervention and a coronary artery bypass graft. The costs of these procedures were estimated using a bottom-up approach. For example, the

cost of a percutaneous coronary intervention included time in the catheter laboratory using the laboratory overheads, the time and number of nurses and physicians involved, the per-use cost of the equipment and the cost of disposable supplies and drugs. The costs of staying in hospital also had to be estimated. These cost included hotel costs, such as utilities, laundry, kitchen services and maintenance, and overhead costs, such as general nursing and pharmacy overheads. The long-term costs of managing patients who had a disabling stroke was approximated using the cost of nursing home care. The average rate of procedures, diagnostic tests, dose of medications, length of stay in a hospital bed per patient were multiplied by the appropriate cost to estimate the unit cost per patient of each treatment arm of the study.

Griebsch et al. (2006) (45) investigated the cost effectiveness of screening with contrast enhanced MRI versus screening with mammography for women with a high familial risk of breast cancer in the UK. Data were collected on staff levels, consumables, equipment, maintenance costs, capital costs and overheads. The cost of the contrast material was based on the woman's weight. Information on the amount of time associated with screening and diagnosing patients was applied to the midpoint of the salary scale (plus national insurance and employer's contribution to pension) of each relevant member of staff to calculate the cost of staff. Due to specific requirements of the clinical research protocol, some equipment, consumable and staff costs were adjusted. The cost of the contrast material was reduced due to the introduction of a generic. Staff time needed was reduced due to greater familiarity with the process. The cost of MRI equipment was reduced to more closely reflect clinical MRI machines than high specification MRI machines used in research. These unit costs of resources were attached to the resource utilisation of the different treatment arms to estimate the unit cost per patient of each treatment arm.

Sculpher et al. (2002) (48) undertook a cost analysis of coronary angioplasty versus medical therapy for angina in England. Information on resource use and cost was mainly sourced from five regional referral centres (two in London, one in the midlands and two in the north of England. Centre specific unit costs for a coronary arteriogram, percutaneous transluminal coronary angioplasty and coronary artery bypass graft were estimated. These estimates incorporated the costs of medical and nursing staff, procedure related drugs and anaesthetics, equipment, consumables and an allocation of relevant overheads. Each of the five centres also provided the allocation costs of some medical equipment. Ward costs were excluded from the procedure costs and estimate separately. Ward costs included the costs of medical and nursing staff, equipment, consumables and an allocation of relevant overheads. The unit cost of the procedures and ward costs was an

average across the five centres. The unit costs of GP visits, inpatient wards, district nurse visits and pharmaceutical prices were sourced from the literature.

Mujica Mota et al. (2006) (50) evaluated the costs of out of home day care for families living in a disadvantaged area of London. The costs of centre-based care were calculated using a bottom-up approach with one exception. The unit cost of private nurseries was estimated through a telephone survey of 20 providers. The unit cost of day nurseries were derived for three different age cohorts of children between the ages of six months and five years. Unit costs for other childcare services were derived from information about local childminders and playgroups. Unit costs of council funded playgroups were estimated by dividing total expenditure by the number of child sessions per year. The unit costs of health and social care services were sourced from the literature. The cost of travel to seek health care was assumed to be twice the typical cost for a London journey. The unit costs of each resource were multiplied by resource utilisation to estimate the unit cost of out of home day care per mother.

6 Summary and conclusion

Irish studies included in this review that calculated unit costs fell into the disease/setting specific category or the health technology assessment category. Most of these studies used a bottom-up or a mixture of a bottom-up and top-down approaches. These studies made use of existing repositories of costs, such as HIPE and the MIMS Ireland catalogue, where possible and engaged in the estimation of unit costs where practical. The data necessary to calculate unit costs, especially from private providers, are not always available to researchers. Similarly, data necessary to calculate unit costs are not always routinely collected in a form that is accessible to researchers.

PSSRU unit costs and unit cost methodologies are heavily cited, particularly in the UK. Indeed, there is some evidence of PSSRU unit costs being used in an Irish context (19) and of PSSRU methods being adapted to an Irish setting (17). Evidence of another comparably referenced research unit or institute in Ireland, the UK or further afield was not found in the course of this review. A higher proportion of studies reviewed used a bottom-up approach to estimate unit costs or sourced unit costs that had been estimated using a bottom-up approach. Bottom-up approaches dominated when there may have been a greater need for precision in estimates, such as in health technology assessments, or when the extra data requirements of the bottom-up approach were not as penalising, such as with disease/setting specific studies. In contrast, the proportion of studies that opted to use a top-down approach was higher among studies that needed to estimate

unit costs across a wide range of services and diseases, that is, non-disease specific studies and health and social care projection models. This may have been due to the increasing penalty of larger data requirements, and so research time, skills and funds, associated with using a bottom-up approach across a broad spectrum of services.

At present, the Irish system suffers from lack of a centralised unit, like the PSSRU in England, tasked with producing annual volumes of unit costs for health and social care. The development of comprehensive unit cost profiles for Irish health and social care services would be of significant benefit to researchers, policymakers and wider health system stakeholders.

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Appendix

Table A1: Approach used, useful life of equipment specified, discount rate used for the cost of equipment and the use of direct care and supportive cost centres by study type.

Study Type	Approach			Useful Life of Equipment			Equipment Discount Rate				Cost Centres Used [a]
	Bottom-up	Mixed	Top-down	5 years	10 years	Other	3%	3.5%	5%	Other	
Projection Models	-	1	3	-	-	1[b]	-	-	-	-	-
Irish											
Disease/Setting Specific	4	1	1	2	1	-	-	1	1	1[c]	-
Health Technology Assessment	-	1	-	-	-	-	-	-	-	-	-
Guideline	1	-	-	-	-	-	-	-	1	-	-
Total (Irish)	5	2	1	2	1	-	-	1	2	1	-
International											
Non-Disease Specific	7	2	4	1	-	-	2	1	-	-	4
Disease/Setting Specific	8	5	-	1	2	1[d]	1	-	-	1[e]	4
Health Technology Assessment	4	1	1	-	-	-	-	1	-	-	-
Total (International)	19	8	5	2	2	1	3	2	-	1	-

Notes
a The study used direct care and support cost centres, with support centre costs being allocated to direct care centres according to a decision rule
b Equipment has a useful life of 8 years
c Equipment is discounted at a rate of 4 per cent
d Equipment has a useful life of between 2 and 5 years
e Equipment is discounted at a rate of 6 per cent

Table A2: Useful life of equipment specified, discount rate used for the cost of equipment and the use of direct care and supportive cost centres by study approach.

Study Approach	Number	Equipment Lifespan			Equipment Discount Rate				Cost centres used [a]
		5 years	10 years	Other	3%	3.5%	5%	Other	
Bottom-up	24	3	2	1[b]	1	2	2	2[c]	-
Mixed	13	1	1	-	1	1	-	-	5
Top-down	9	-	1	1[d]	1	-	-	-	3

Notes
a The study used direct care and support cost centres, with support centre costs being allocated to direct care centres according to a decision rule
b Equipment has a useful life of between 2 and 5 years
c Equipment is discounted at a rate of 4 and 6 per cent respectively in each study
d Equipment has a useful life of 8 years

Year	Number	Title/Author(s)
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