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What is health economics?

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Objectives: This paper describes the principles of economics and their application to the promotion, protection and restoration of oral health in populations and the planning, management and delivery of oral health care. After illustrating the economic determinants of oral health, the demand for oral health care is discussed with particular reference to asymmetric information between patient and provider. The reasons for the market failure in (oral) health care and their implications for efficiency and equity are explained. We go on to describe how economic evaluation contributes to policies aimed at maximising oral health gains where resources are constrained. The behavioural aspects of patients´ demand for and dental professionals´ provision of oral health services are discussed. Finally, we outline methods for planning the dental workforce in ways that reflect system goals.

Keywords (MESH compliant):: *Oral Health, Economics, Resources, Health Resources, Human Resources, Efficiency, Insurance, Affordability, Pricing, Reimbursement, Fee-for-Service, Costs and Cost Analysis, Cost allocation, Direct service costs, Employer health costs, Health expenditures, Cost-benefit analysis, Cost sharing, Income, Salaries, Workforce.*

The economic problem: Getting the most out of our resources

Economics is concerned with maximising benefits from the resources available to us (the constrained maximisation problem) and is based on three fundamental principles; ***Scarcity***, ***choice*** and ***opportunity cost***. *Scarcity* occurs when the available resources (e.g., number of dentists) are less than the resources needed for everything we would like to do (e.g., provide all effective care to everyone). So *choices* must be made about how to use whatever resources are available. These choices are often difficult. Should we use funds for a more effective but more expensive material to fill decayed teeth if this means that fewer teeth could be filled? Moreover, making more resources available for oral health care does not avoid choices having to be made about (1) redirecting additional resources from their current use and (2) making best use of these additional oral health care resources. *Opportunity cost* (the highest valued alternative use of resources) represents the economic basis for making these choices. Hence, if the benefits generated from the way we *choose* to use resources exceed the benefits generated by using the same resources in their most productive alternative uses (i.e., the *opportunity cost*), then we have used the available resources efficiently.

Health economics is concerned with applying these principles to problems of health and health care. However, health and health care present particular challenges for the application of the economic principles because they have characteristics that make them different from standard goods and services bought and sold in private markets. This means that intervention in the market for dental care is required if we are to use available resources efficiently. Problems of health and health care require particular attention from economists in order to consider the use of resources devoted to producing health care and improving oral health.

In order to quantify the economic impacts of oral health and care, it is relevant to identify the direct costs (treatment expenditures), indirect costs (productivity losses due to absence from school and work) and intangible costs in terms of detrimental impacts on people's quality of life (Listl *et al*., 2015a). Globally, dental diseases accounted for direct costs of US$356.80 billion and indirect costs of $187.61 billion in 2015. For the EU-28 countries, dental diseases gave raise to treatment expenditures of approximately €92 billion and productivity losses of €52 billion in 2015 (Righolt *et al*., 2018). Dental expenditures are substantial, both in absolute terms and relative to the costs of addressing other diseases (see figure 1). In terms of the impact of dental diseases on quality of life, the quality-adjusted life expectancy (QALE) loss due to dental conditions was estimated to account for 5.3% of QALE loss due to overall morbidity in the US adult population (Matsuyama *et al*., 2019b).

In the rest of this paper we introduce the different ways economics is used to address the efficient production of oral health in populations, which includes, but is not limited to the planning, management, production and delivery of oral health care. We start by illustrating the economic determinants of oral health. We then discuss the demand for oral health care, with particular reference to asymmetric information between the patient and provider. The reasons for market failure in (oral) health

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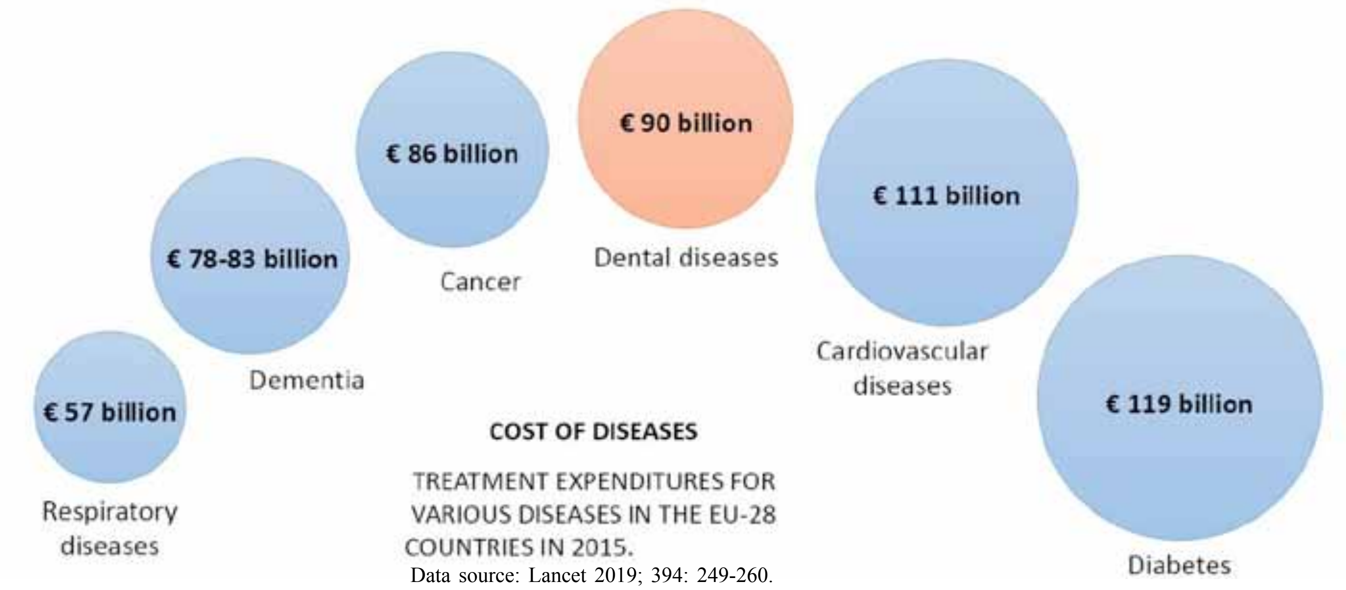

Figure 1. Treatment expenditures for various diseases in the EU-28 countries in 2015.

care and its implications for efficiency and equity are explained. We then describe how economic evaluation contributes to policies aimed at maximising oral health gains where resources are constrained. The behavioural aspects of patients´ demand for, and dental professionals´ provision of oral health services are discussed. Finally, we outline methods for planning the dental workforce in ways that reflect system goals.

The production of health

Health is a source of value, i.e., along with other goods and services, it generates utility, or well-being, for the individual. In economics, utility is a term used to describe the satisfaction an individual gets from the consumption of commodities. However, health cannot be purchased directly. Instead it is 'produced' by the levels and combinations of factors that influence health and the risks of disease (i.e., health determinants). Some of these factors can be purchased directly (private goods such as toothbrushes, toothpaste, oral health care), while others may be in the form of a public good such as water fluoridation. The individual may have little control over exposure to some of these determinants, either because of the characteristics of the individual (e.g., insufficient funds to purchase the private good) or the good (e.g., the individual cannot avoid exposure to a public good).

Although health care is an important determinant of health (Gulliford, 2009), other factors also influence health, e.g., an individual's genes (De Coster *et al*., 2009), lifestyle e.g., smoking behaviour (Carr and Ebert, 2012) or participation in activities with risks for tooth trauma (Lahti *et al*., 2002; Schildknecht *et al*., 2012), diet (Burt and Pai, 2001) etc. as well as limitations placed on choices about many of these factors by the individual's income, educational attainment and wealth throughout the life-course (e.g. Listl *et al*., 2014; Shen and Listl, 2018; Matsuyama *et al*., 2019a). This concept of multiple determinants of health is called the *health production function* (Rosenzweig and Schultz, 1983). The relationship between a particular health determinant and health is often complex and conditional on the levels and mix of other health determinants. For example, the improvement in oral health (or reduction in risk to oral health) produced from health care may depend on the environment in which an individual lives (the fluoride content of the water supply), lifestyle (smoking, types of foods and drinks consumed) and the skills of the care provider etc. Economics provides a means of analysing the production of health.

The estimation of health production functions (the mathematical relationship between health determinants and health outcomes) by means of empirical econometric methods enables us to consider

1. The returns on investment in health determinants across a range of *different levels* of investment. For example, does the change in health produced from toothbrushing differ with brushing frequency (see e.g. Twetman, 2009)? This is similar to the dose-response relationship in clinical research.
2. Whether the returns on investment differ among a range of *different health determinants*. For instance, identifying the causes of social inequalities in oral health and the related contributions of econometrics (Listl and Wildman, 2015; Kakwani *et al*., 1997). Another example is the question of whether investing resources in improving oral hygiene produces more health gain than investing the same amount of resources in water fluoridation (Weintraub, 1998).
3. Whether the return on investment in a particular health determinant is *conditional* on the levels of other health determinants. For example, is the level of caries prevention produced in response by water fluoridation conditional on the socio-economic circumstances of the population (Birch, 1990; Glied and Neidell, 2010)?

The health production function *describes* the relationship between health determinants and health outcomes, but doesn't explain the particular levels of health determinants and why these differ between individuals and between populations. Grossman (1972) developed an economic model of individual health behaviour, or *demand for health*. Under the model, individual behaviour is determined by the balancing of the benefits and opportunity costs of health change. Benefits incorporate two components, consumption (the utility change from feeling healthier or less healthy) and investment (the utility change generated from the impact of health change on income earning capacity or the capacity to engage in leisure activities etc.). These benefits are measured by the individual's valuation of these 'consequences' of health change.

Similarly, opportunity costs are measured by the impact on the individual's well-being of what s/he has to forgo to achieve the health change. The benefits and/or opportunity costs of *the same health changes* may differ between individuals leading to them behave differently. The health change could be associated with different impacts on earnings capacities. Glied and Neidell (2010) found that the impact of oral health status on earnings differs between women and men. The opportunity costs differ if the individuals have to forgo different things (e.g., the costs of fluoridated toothpaste relative to income may vary between industrialized and developing countries (Goldman *et al*., 2008), or if the effect of this sacrifice on utility differs between individuals. Hence differences in health determinants between two individuals, such as smoking for example, need not be the result of a poor choice by the individual who smokes (Birch *et al*., 2005) even though health agencies, concerned with improving the health of populations might prefer that they make more healthy choices. Given the circumstances (or context) faced by the individual, choosing to smoke may represent optimal (i.e., utility maximising) albeit non-healthy behaviour (i.e., a lower demand for health) and public interventions aimed at improving health may thus be of limited effectiveness. The Grossman model provides a way of understanding individual behaviour and emphasises the need to design healthy public policies in ways that respond to the varying contexts and circumstances of individuals. In other words, if we want individuals to behave differently we need to find ways of ensuring individual well-being increases by doing so (Birch, 1999).

The production of health care, derived demand and asymmetric information

Health care, like many other goods and services (but unlike health), can be purchased directly, either by patients or public agencies. However, unlike many other goods and services, health care is not a direct source of utility for an individual. Individuals prefer not to consume health care because it may involve pain, discomfort or inconvenience. Health care is consumed only for the expected impact on health status. Hence the demand of health care is *derived* from the net increase in utility arising from the expected health gain after allowing for any reductions in utility associated with treatment (pain, anxiety, side effects).

Individuals have limited knowledge of what health care is required to achieve a desired health improvement. They seek the advice of health care professionals, who have greater knowledge of the relationship between health care and health, to determine what health gain can be expected from different treatment options. This *asymmetry of information* between the consumers and the providers of health care means that the demand for health care, although derived from the individual's expected health gain, is based on the advice and direction of health care providers[1]. The demand for health care is thus *induced* by the suppliers of care through their role as advisor, or agent, of the patient (in other words: there is no independent demand curve). Supplier induced demand is not a problem *per se* because we want individuals with health problems to seek the advice of health care professionals before determining what care to choose. However, this means that the demand for health care cannot be determined solely by consumers. This represents the defining characteristic of health care that separates it from other goods and services. Providers of care therefore have a potential conflict of interest in advising patients, because providers also draw their incomes from providing care. Consequently, the market for health care requires intervention if resources are to be used to maximise health gain.

Several studies support the supplier-inducement hypothesis within dentistry (see Grytten 2017a). In most studies where supplier inducement hypothesis has been examined, the outcome has been some measure of dental service utilisation (for example costs per visit, types of treatment). Typically, they find increases in utilisation as the supply of dentists increases. A particular concern is the situation in which supplier-induced demand has a negative impact on dental health. This was the case in a large US study in which dentists filled healthy teeth as a response to increased competition and lack of patients (Grembowski and Milgrom, 1988). Similarly, a recent study found that when dentists changed from non-incentive to incentive-based payment systems, the number of potentially harmful dental x-rays increased (Chalkley and Listl, 2018).

In an unregulated market any individual could set themselves up as an 'expert' in diagnosing health problems, recommending treatment and delivering the care. However, the potential adverse consequences of 'rogue' experts are profound (pain, suffering, disability or death). Supply is therefore organised through restrictions on market entry (licensure) to those with defined qualifications and professional codes of practice are used to protect the public interest. This limits supplier inducement to qualified practitioners, but the demand for care remains influenced by supply, thus market mechanisms fail to achieve the socially optimal allocation of health care resources. In particular, providers' recommendations for care may partly reflect the workload (and hence income) expectations of providers. As a result, the levels of services used may not reflect (only) patients' needs for those services, and supplier induced demand may lead to care being provided in ways that do not maximise health gain from available resources. Commissioning services by a third party such

[1] The expertise of the provider is however limited to this relationship with the individual having expertise in the association between health and well-being, i.e. whether the increase in health expected from a particular health care intervention generates a net increase in utility, and which treatment option produces the greatest expected increase in utility.

as a local health authority, is an attempt to limit the role of supplier inducement by funding service provision by providers based on the needs of the population being served (Whittaker and Birch, 2012).

There are different ways of producing health care and the challenge is to find the most efficient methods, i.e., those that maximise health gain from available health care resources. Figure 2 illustrates the dependencies between inputs that form the basis for the production of (oral) health care outputs, which in turn shape (oral) health outcomes. Thereby, the methods of production determine the particular levels and mix of inputs and represent the health care production function (the mathematical relationship between health care inputs and health outcomes). This enables us to explore ways of increasing health gains through the use of different mixes of inputs (or substitution between inputs). For example, the production of primary oral health care services could be changed by deploying more dental therapists and dental hygienists and fewer dentists (Harris and Sun, 2012). Decisions about the methods of service delivery must be informed by evidence of the outcomes and costs of the various ways of producing services and supported by policies that enable more efficient methods of service delivery to be used.

Health care often involves episodes that are made up of a complex series of complementary services (e.g., prevention, treatment and rehabilitation). The health outcomes produced in each element within the episode may not be additive. Instead, the outcome from a given procedure may depend on the quantity and type of prevention and or rehabilitation received. For example, the survival of a dental implant may depend on the level of professional oral hygiene instruction (Quirynen *et al*., 2002). The efficiency of services must therefore be evaluated in the context of the episode of care that a patient experiences as opposed to service elements that separate providers deliver.

The health care production function allows us to compare different methods of producing services in order to address the constrained maximisation problem. The estimation of production functions enables us to consider:

1. The returns on investment in healthcare inputs across a range of *different levels* of investment. For example, does the change in oral health in a population produced from increasing dentist supply change with the baseline level of dentist supply? This is similar to the dose-response relationship in clinical research.
2. Whether the return on investment differs among a range of *different health care inputs*. For example, does investing resources in training more dentists produce more oral health gain than investing the same amount of resources in training more hygienists?
3. Whether the return on investment in a particular health care input is *conditional* on the levels of other determinants. For example, is the health gain from increasing the supply of dentists conditional on the supply of dental hygienists in the population?

Methods to evaluate the causal impact of interventions to improve oral health

A key goal is to assess accurately the impact of interventions that may improve (oral) health. Randomised controlled trials have been considered the gold standard for causal inference in medical and dental research. But in the absence of randomised experiments, identification of reliable intervention points to improve oral health can be a challenge. In this regard, the health economists' toolbox provides a number of suitable alternative methods for causal inference using observational data such as difference-in-differences (DiD) analyses, instrumental variables (IV), regression discontinuity designs (RDD) and fixed-effects panel data analysis (see e.g. Listl *et al*., 2016 and Grytten, 2017b). For example, a recent study employed an instrumental variables approach to examine the effect of education on oral health later in life. Exogenous variation in the duration of schooling (due to schooling reforms) was used to detect the causal impact of education on tooth loss in older age (Matsuyama *et al*., 2019a). Similarly, a schooling reform has previously been exploited to examine the impacts of education on dental care use (Grytten and Skau, 2017, 2018).

Health care economics: The demand and supply of health care

Health *care* economics is concerned with the demand and supply of health care, including the behaviour of providers and consumers of care and the evaluation of services. It considers the impact on the health and well-being of individuals and populations of using available resources in alternative ways by comparing both the effects (outcomes) and costs of different interventions (economic evaluation). Such evaluations are, in isolation, descriptive information on the expected rate of return on additional investment (what extra outcome can be produced by investing more

Figure 2. The relationship between inputs, outputs and outcomes in the production of (oral) health care

resources in this particular treatment?). In addition, the opportunity cost of the additional investment (what has to be forgone in order to provide the additional investment required) determines whether this rate of return represents an efficient use of resources. Consideration must also be given to ensuring that services evaluated as being efficient will be produced by providers and consumed by patients in the way intended. Hence health care economics extends beyond the area of economic evaluation of interventions to incorporate the study of the behaviour of providers and consumers. For example, when evaluating a new screening service (e.g. the use of salivary cytokines as a screening tool for oral squamous cell carcinoma; see Osman *et al*., 2012), health care economics would involve *inter alia*:

1. Estimating the additional costs and effects of the new service compared to existing practice
2. Calculating the expected rate of return on additional investment (additional effects divided by the additional costs)
3. Considering alternative ways of supporting the additional investment within the existing resource constraint and the forgone effects associated with taking the resources required from these other uses
4. Analysing the behaviour of patients and providers concerning who uses care and what care is delivered.
5. Modelling the required amount of care to be delivered and the required number and mix of providers to deliver the care.

Activities 1-3 represent the area of economic evaluation of health care programmes, 4 involves studying provider and patient behaviour (behavioural economics), while 5 concerns creating the optimal capacity to support the provision of the right amount of care to the right patients (service and workforce planning).

Economic evaluation of health care

Economic evaluation has been defined as "ensuring that the value of what is gained from an activity outweighs the value of what has to be sacrificed" (Williams, 1983), reflecting the fundamental principles of scarcity, choice and opportunity cost. In order to determine whether the benefits produced by a particular programme exceed the opportunity costs of providing that programme, a method of measuring and comparing outcomes is required. Because different programmes aim to produce health gains in different patient groups, they often involve very different types of health gain. For example, some oral health programmes may be aimed primarily at retaining and restoring teeth (restorative care) while others aim to improve function (orthodontics). Even among programmes aiming to achieve the same outcomes (e.g., composite versus amalgam tooth restoration), the programmes often differ in other important aspects of outcome (e.g., the appearance of the filled tooth). Hence economic evaluation involves comparing outcomes across different health programmes.

Between-programme comparisons of outcomes adopted has often involved a measure that combines the expected period of health gain (quantity) with the expected improvement in health (quality) into a Quality-Adjusted Life Year (QALY), using patients' preferences between different health states to weight time periods spent in those states. An equivalent quality-adjusted measure of time in different oral health states has also been developed for use in oral health programme evaluations, the Quality Adjusted Tooth Year or QATY (Birch, 1986). By basing the measurement of quality on patient (or public) preferences among different health outcomes, it is sometimes argued that the analysis will identify which programme maximises social well-being (i.e., by interpreting the QALY to be a measure of patient health related well-being). However, the method of measuring QALYs separates quality and quantity of health into independent dimensions with quality scores for health states being multiplied by the number of years in each health state (Williams, 1985; Birch, 1986). This assumption of separability implies that health states have values that are independent of the duration in that state as well as being independent of the states of health experienced before the current and expected states. It limits the impact of a particular state on the patient utility to be proportional to the amount of time spent in that state and prevents an individual from expressing a preference that doesn't fit this arbitrary model (Gafni and Birch, 1993). Under such a model dental anaesthesia would be of little value to patients because the pain, suffering and anxiety relieved is for such a short duration that it would have a QALY value of close to zero. Yet as Gafni and Birch (1993) argue, many individuals express a strong preference for anaesthesia via their willingness to receive (and pay for) it during dental procedures.

Other approaches have been developed to overcome these limitations of the QALY model. The Healthy Year Equivalent (HYE) makes no assumptions about the separability of quantity and quality in patient preferences among health states (Gafni *et al*., 1993; Gafni and Birch, 1997) but still assumes that the utility of health gains is independent of all other aspects of an individual's life. If utility maximisation is the objective, a more generic outcome measure is required in the form of 'willingness to pay' for the intervention. This allows for comparison between different types of health programmes, as well as between health and other programmes (Matthews *et al*., 1999; Birch *et al*., 2004). Although the use of WTP has been criticised because of the influence of an individual's ability to pay (ATP) (e.g., income) on the individual's stated WTP, and hence may favour those with higher incomes, the same equity problem has been shown to apply to the methods used for measuring QALYs (Donaldson *et al*., 2002). Methods have been developed to address the effect of WTP on differences in ATP (Donaldson *et al*., 1997).

Cost effectiveness analysis

Cost-Effectiveness Analysis (CEA) is the most common method of economic evaluation in health care, aimed at informing decision makers faced with maximising benefits from constrained resources (see e.g. Listl *et al*., 2010). It compares the difference in effects between a programme under consideration and the current way of serving the same patient population (incremental effects), and the difference in costs between the two programmes (incremental costs). Where incremental costs and incremental effects have different signs, the solution is trivial, e.g., the new programme costs more (i.e., reduces resources available for other unrelated programmes) and produces less effects than the current programme. In most cases, however, a new intervention involves incremental effects and incremental costs that are in the same direction, e.g., the intervention is more effective but costs more than the existing intervention. To provide the greater effects of the new treatment, the number of other unrelated treatments must be reduced to release resources to fund the new treatment. Here the decision-maker looks to the economist for 'inputs' to aid decision-making – in particular decision rules for CEA.

The analytical tool of CEA is the incremental cost-effectiveness ratio (ICER), the incremental cost divided by the incremental effects. Maximum health gain from available resources is produced by selecting programmes in ascending order of ICER (i.e., project with lowest ICER first) until available resources are exhausted (Weinstein and Zeckhauser, 1973). Because ICERs have not been estimated for all programmes, comprehensive ICER 'league tables' are not available and the rule cannot be followed. Instead, a threshold ICER approach has been adopted, under which programmes are selected if the ICER is less than or equal to λ. This threshold rule has provided the basis for economic evaluation guidelines in many jurisdictions (Gafni and Birch, 2006).

Calculating the ICER produces an *average* cost per additional unit outcome (or inverse of the average rate of return on additional investment) and implies that the rate of return on additional investment is constant (constant returns to scale). Unfortunately, programmes are not divisible into individual units of outcome (perfect divisibility). For example, increasing investment in a particular programme is unlikely to produce proportionally equal increases in outcomes as programme coverage expands to lesser need/severity groups. So, the additional outcomes produced from investing resources in a programme may diminish with the scale of the programme. Thus, the conditions required for the CEA to result in an efficient allocation of health care resources do not hold. Likewise, a manager who purchases an entire Digital Volume Tomography machine, cannot divide the cost or outcomes into chunks to fit whatever budget the decision-maker might have, it is "all or nothing". Some programmes may not be divisible because of political or ethical constraints. It is unlikely that a decision-maker could introduce a programme with a capacity to screen only 50% of children at risk.

Even if the programme does exhibit constant returns to scale, the opportunity cost is likely to have non-constant returns. The increased resource requirements for the new programme mean the decision maker has to 'dig deeper' into the existing budget to fund it. After resources from the least productive current programme have been exhausted a decision-maker must look to other more productive programmes, meaning that the opportunity cost of the programme per unit expansion increases with the size of the programme.

Because decision-makers face choices between programmes of different sizes and the opportunity costs of programmes depend on programme size, new and existsing programmes for the same patients are rarely directly comparable. Each programme produces a quantity of health gain and the average price per unit health gain may vary with programme size. Consequently the ICER threshold is not sufficient to maximize health effects from available resources and the strategy of selecting the programme with the lowest cost-effectiveness ratio cannot be justified on the basis of efficiency in resource allocation (Listl and Birch, 2013). Moreover, the threshold ICER value required to make decisions that maximise health gains from available resources cannot be determined, because information on the incremental costs and effects of *all* possible programmes is not available and hence the opportunity cost of the least efficient programme currently funded cannot be determined. Instead, decision makers have adopted arbitrary thresholds that bear no relation to maximising health gain (Birch and Gafni, 2006). This has led Drummond (2012) to note that "the impact of economic evaluation on the allocation of healthcare resources is hard to ascertain".

Extending economic evaluation to identify efficiency improvements

For an intervention to represent an efficient use of resources the additional effects it generates must exceed the effects forgone from the most productive alternative use of the same resources. Hence, efficiency cannot be established by reference only to the resources required and outcomes produced by a particular intervention. Information on alternative uses of those resources is also needed, and thus efficiency is context specific (Birch and Gafni, 2003). Even where the incremental costs and effects of an intervention are identical in different settings, it does not mean the efficiency of that intervention is the same in all settings (Birch and Gafni, 2002).

If economics is to inform decision-makers about the efficiency of investments, CEA and the use of ICERs are insufficient. Mathematical approaches to constrained maximization such as integer programming (IP), solve the decision-maker's problem and are the only universal approach to ranking programmes according to efficiency under a resource constraint (Drummond, 1980). The key requirement of the IP approach is that the specification of the problem (i.e., objective function and constraints) must accurately reflect the decision-makers problem setting. Tianviwat and colleagues (2009) recently applied this approach to delivering primary dental care to schoolchildren.

The substantial data requirements of IP, specifically the incremental costs and effects of all programmes together with the resources available for investment, may be difficult to satisfy. However, they reflect the complex nature of the decision-maker's problem. Birch and Gafni (1992) present a practical alternative that satisfies a modified objective of an unambiguous increase in health improvements from available resources (i.e., an objective of improving as opposed to maximising, efficiency). This requires the health improvements of the proposed programme be compared with the health improvements produced by that combination of programmes that must be given up to fund the proposed programme. Only where the health improvements of the proposed programme exceed those of the sacrificed programmes does the new technology represent an improvement in efficiency. This approach does not rely on an arbitrarily ICER threshold to ascertain the efficiency of the programme, nor is it dependent on unrealistic assumptions about perfect divisibility and constant returns to scale. Instead, the source of additional resource requirements is identified and the implications of cancelling programs to generate these resources form part of the analysis. Iterative application of this efficiency-*improving* approach would eventually lead to efficiency *maximisation* as opportunities to further improve efficiency are exhausted.

Programme Budgeting Marginal Analysis (PBMA) is an approach to incorporate the opportunity cost of new programmes explicitly into decision-making (Mitton and Donaldson, 2004). Here decision makers are required to identify possible programmes to be reduced or removed from existing budget allocations in order to liberate additional resources for a new programme. The decision maker can then directly compare the additional benefits expected from the new programme with the forgone benefits of the programmes that need to be reduced to generate the additional resources. However, as with CEA, the comparisons between the new and forgone programmes are based on their ICERs. As Birch and Gafni (2015) note, the marginal analysis, based on the estimated benefits forgone from one additional unit of resources diverted to the new programme, needs to be replaced with incremental analysis, based on the estimated benefits from the total additional resources diverted to the new programme. PBMA therefore remains restricted by the assumptions of perfect divisibility and constant returns to scale of CEA.

Maximizing health improvements from available resources may be one of several objectives that decision-makers face. Political considerations associated with providing equal access to services and providing greater priority to health improvements of specific population groups may be important goals. However, multiple objectives and constraints do not reduce the importance of adopting a constrained maximization model as the basis for analysis. Whatever goals are identified must be pursued efficiently in order to avoid wasting resources (Williams and Cookson, 2000). The explicit identification of each objective and constraint enables the full range of policy concerns to be incorporated systematically into the analysis. Hence, the complex objectives faced by decision-makers, far from limiting the role of economic analysis, represent precisely the challenges that the economic model of constrained maximization is intended to accommodate.

There is room for improvement in the quality of reporting of health economic evaluations as limitations in the comprehensiveness of conducting, reporting, and publishing economic evaluations in dentistry may compromise the quality and safety of oral health care (Marinho *et al*., 2013; Tonmukayakul *et al*., 2015; Tan *et al*., 2017; Hettiarachchi *et al*., 2018; Eow *et al*., 2019; Qu *et al*., 2019).

Understanding the impact of economic factors on patient and provider behaviour

Health problems can be caused by low income. Conversely, health problems can reduce income if they restrict normal activities. As a result, an individual's need for health care is greatest when his/her ability to pay for it is lowest. Likewise, populations with greater needs will tend to have lower capacity to meet them – what has been referred to as the *inverse care law* (Hart, 1971). To allocate health care resources in ways that maximize health gain, we must understand what determines this mismatch between use of and need for care, so that we can evaluate methods for planning and allocating resources in accordance with relative needs. Health economics addresses this 'conundrum' by analysing alternative approaches for funding service provision, allocating resources for the capacity to care and managing performance. Government intervention in response to market failure does not mean that resources will necessarily be allocated efficiently. The threat of 'government failure' to maximize health gain is similar to the threat of market failure. Hence health care economics involves developing and evaluating methods to plan for and allocate health care resources in the absence of the market.

For example, public funding for oral health care aimed at reducing or removing the price of care paid by patients, has been used to improve access among the population, and hence increase the efficiency of resource use. Yet despite many years of public funding, oral health inequalities remain (see e.g. Watt *et al*., 2015; Shen and Listl, 2018). This policy failure arises from the simple models of access to care that underlay public funding models in which access to care is implicitly viewed as being determined by cost to the patient at the point of delivery (i.e. the patient charge).

Understanding the determinants of using care

Andersen and colleagues (1968) presented a model for understanding differences in the use of care within a population. The determinants were categorised broadly into need, predisposing, enabling and system factors. Predisposing factors are individual characteristics, such as education, that might predispose to use other things equal, because of greater understanding of symptoms. Enabling factors relate to individual characteristics that may support or constrain the individual using care (such as the individual's income, as a means of paying for care and the costs associated with travelling to care providers) while system level factors relate to the way care delivery is organised in a population (e.g., geographic distribution, appointment and referral systems etc). Removing the cost of care at point of service delivery will not lead to care being used in accordance with need if the system, predisposing or other enabling factors remain unequal. Hence policies to overcome market failure must embrace a broader perspective on the determinants of use.

For illustration, a recent study used the Andersen framework to examine why Europeans aged 50+ had not sought regular dental care. Need and predisposing factors (dental care perceived to be "not necessary" or "unusual") were more frequent reasons for non-attendance than enabling factors (e.g. care being "not affordable") or the system level factor of "no provider nearby" (Listl *et al*., 2014).

McIntyre et al. (2009) present a framework in which access to care is determined by three broad dimensions, affordability (the full costs to the patient of receiving care in relation to his/her ability to meet those costs), availability (the location, time and eligibility criteria for using care) and acceptability (the way care is delivered). Under this framework, care remains inaccessible, even when it is free to the patient, if it does not satisfy patient expectations and constraints concerning where and when it is offered, how it is delivered and the costs to the patient of attending. If those with greatest need also have greatest challenges of affordability, availability and acceptability, then subsidising care at the point of delivery will simply increase government expenditure without affecting the distribution of care. Instead, those already using care receive a transfer of wealth from the government, as they now pay less for the care they receive, while care remains inaccessible to those with greatest needs. This suggests that models of care used in planning service provision must reflect the perspectives of those with needs at least as much as those delivering the care.

Understanding the delivery of care: Paying providers

If resources are to be used to maximize health gain we must ensure that policies are developed to support providers delivering care to the same end. If provider incomes do not respond to the level and mix of needs being served why would we expect them to behave in ways which do reflect the levels and mix of needs? Payment approaches for providers (or 'incentivising' health care delivery) may be salary-based, fee-for-service, capitation, pay-for-performance or value-based. Health economics gives a 'toolbox' to analyse these approaches in the context of the goals of the health care system.

Under **salary-based payments** provider earnings respond to the amount of time devoted to providing care, but not to the type of patient served, how they are served, the number of patients served or the outcomes achieved. So there is no financial incentive to prioritise patients according to their needs or to maintain high levels of productivity (hence rewarding "on-the-job leisure"; Robinson, 2001). Salary-based approaches are an effective way to control cost per provider (through salary controls), but controlling total costs may remain elusive if funders respond to apparent shortages of providers indicated by problems of access (e.g. waiting times) but caused by low productivity, by increasing the number of providers beyond the efficient level (i.e., that associated with a productive workforce) and hence increase total costs. Expenditure is the product of the number of providers and the mean level of salary. It does not relate to the size of the population being served or the needs for care within the population.

Under **Fee-for-service payments** (FFS) provider earnings respond to the quantity and mix of services delivered, thus providing strong incentives to increase service productivity. Provider income does not respond to the type or numbers of patients served or the outcomes achieved. So providers paid FFS have no financial incentive to prioritise patients according to need or to expand their patient lists. In this way FFS incentivises over-treatment (Birch, 1988) and distorts the level and mix of service provided among patient groups with different levels and forms of coverage (Birch, 1988; Chalkley and Tilley, 2006). This suggests that the extent to which patients are able to bear the costs of treatment may constrain the FFS provider's ability to expand services, but it doesn't distinguish between services on the basis of patient need. For example, dental x-rays are utilized more often if providers receive FFS instead of salary payments and if patients become exempt from treatment charges (Chalkley and Listl, 2018). Cost control is a major problem under FFS because total expenditure is the product of the number of providers and the mean number of services per provider (adjusted for the mix of services). As with salary-based payments, total expenditure does not relate to the size of the population being served or the need for care within the population.

Under Capitation provider earnings respond to the quantity and type of patients served, thus providing incentives to expand patient lists and serve higher needs patients. It represents a payment for taking responsibility for an individual's health care needs by paying a predefined amount per period for each enrolled patient independent of whether or not the patient receives any care, or the type of care received. Provider income increases with the number of registered patients but decreases with treatment intensity. Ellis and McGuire (1996) argue that the disadvantages of capitation are that providers can increase incomes by selecting patients with low treatment needs (a *selection effect*), decreasing the number of services per patient (a *moral hazard effect*), and by narrowing the scope of provided services (a *practice style effect*). Needs-based (or risk-based) capitation fees that reflect the expected needs of the patient reduce selection effects, while patient choice among providers can constrain moral hazard if patients dissatisfied with access or the care received when accessing their dentist can move (together with their capitation fee), to another dentist. Failure to provide patient choice (by for example, allowing providers to collude about closing patient rosters) leaves patients exposed to moral hazard. Cost control is less of a problem under capitation because total expenditure is the product of the patient population covered and the mean capitation fee per patient. Hence capitation relates directly to the size of the population being served and the needs for care within it. Dentists choosing to serve larger and higher needs populations will receive higher earnings. Capitation therefore better aligns the objectives of the system (meeting the needs of the populations) with provider reward.

Pay-for-performance (P4P) or **value-based-payments (VBP)** are increasingly discussed as alternatives to conventional payment systems. P4P and VBP intend to link financial incentives with measures that reflect provider performance and thereby improve (oral) health care. However, concerns have been voiced that such payments may imply negative effects (crowding out) with respect to the intrinsic motivation of providers and, hence, result in undesired impacts on actual performance. The application of P4P and VBP in dental care is still very sparse (Grytten, 2017a). Current challenges include the limited availability and applicability of quality measures for oral health care.

Relatively little empirical evidence exists about the impacts of the various types of reimbursement in dentistry (Brocklehurst *et al*., 2013). The existing evidence endorses capitation and salary payments as supporting cost-containment and triggers of patient selection and/or under-treatment. Conversely, fee-for-service payments encourage higher utilization but do not incentivize cost-containment.

Blended payment systems have been discussed as a means to combine the advantages of various types of reimbursement. In this sense, the idea behind a mixed fee-for-service and capitation payment is to avoid the adverse effects and to take advantage of the favourable effects of each (Grytten, 2017a). Therefore, a mixed payment system may produce results somewhere between over- and under-treatment. The prospective component, i.e. the per capita payment, will promote efficiency, while the retrospective component, i.e. the fee-for-service payment, will secure the quality of the care that is provided (McGuire, 2011). But how large should the per capita component be in comparison to the fee-for-service component? This will depend on the characteristics of the population served. For example, in most Western European countries, most children and adolescents have good dental health, with little treatment need. Within such a population, the per capita payment should be large to encourage high productivity, which is what we want. Conversely, the fee-for-service payment should be large in a population of elderly people (Grytten and Holst, 2013) in order to reduce the risk of patient selection and undertreatment. To our knowledge, only one study has examined the effect of a combined payment system (Grytten *et al*., 2013). In that study the per capita component led to an increase in the number of patients seen without reducting the quality of dental care.

A summary of the expected effects of various payment methods on dental outcomes is shown in Table 1. Under any payment system, performance appraisal of providers remains important. Payment mechanisms represent methods of allocating resources between providers. Although capitation methods are more consistent with the goal of maximising health gains from available resources, they do not determine how those resources are actually used. Hence, monitoring and surveillance remain essential elements of ensuring appropriate resource use.

Planning the capacity to care

When dental care provision is organized by public authorities, decisions have to be made about the appropriate capacity for providing care. In markets for many other goods and services this capacity emerges from the interaction of supply and demand. However, planning the capacity for health care faces two major challenges.

The absence of an independent demand curve means there is no interaction between supply and demand; in other words, there is no price that clears the dental care market.

Providers of care require investments in long periods of education and training, so decisions about the number of providers to produce have long lead times and long-lasting consequences.

We argued above that in order to maximise health gains decisions about what services to provide are determined in relation to the needs of the population being served as opposed to the preferences of those providing services. As a result, decisions about the size and mix of the health care workforce must be linked directly to decisions about the levels and mix of services required to maximise health gain. In practice there has been little if any integration of workforce and service planning. In this section we identify the problems arising from current methods of health workforce planning and present an approach to integrate workforce and service planning based on population need for care.

The 'inevitability' of workforce shortages

Although the number of practicing doctors per 1000 population in the UK increased by 42% over the first decade of the new millennium, by 23% in Australia, by 19% in New Zealand, 10% in USA and 9% in Canada, each country reported serious shortages of doctors (OECD, 2011) and concerns about the financial sustainability of their health care systems if these increases in supply were insufficient. What explains this apparent never-ending need for more health care, given the changes occurring in population health and the delivery of health care? For example, major improvements have occurred in both oral health (particularly among children), and dentist productivity (associated with changes in the way care is delivered) over the last quarter century of the last millennium (Birch and Maynard, 1985). However dentist numbers continued to increase faster than the size of the population (OECD, 2009). Although one might anticipate reductions in the average workload (and income) per dentist, this ignores the 'rising expectations' in dentistry as reflected by, for example, the rapid expansion of orthodontics among children. Where did this 'expectation' come from? Mothers did not march on parliament demanding governments deal with the problem of children's 'bent' teeth. Nor were governments identifying children's 'bent' teeth being a threat to the economy, national security or general welfare. Instead, dentists, whose workloads were at risk as needs fell and productivity increased, took an interest in straightening children's teeth (for more on supplier induced demand in UK dentistry see Birch, 1988). This was not an unmet need governments *planned* to meet as part of oral health policy. Instead, services expanded beyond the level of orthodontics required for serious cases of malocclusion, to serve non-essential cosmetic cases in order to meet the provider workload expectations when needs were falling.

Table 1. Expected effects of payment methods on dental outcomes

Outcome	*Fee-for-service*	*Capitation*	*Salary*	*Pay-for-performance*
Quantity:				
per patient	Increase	Decrease	Decrease	Decrease/Increase[1]
number of patients (volume)	Increase	Increase	Decrease	Decrease/Increase[1]
Supplier induced demand	Increase	Decrease	Decrease	Decrease
Referrals	Decrease	Increase	Increase	Decrease
Patient selection	Decrease	Increase	Increase	Decrease/Increase[1]
Prevention	Decrease	Increase	Increase	Increase

[1]Depending on how targets are set.

Because workforce planning methods do not respond to changes in the needs of the population or changes in the productivity of providers, the estimated required number of providers increases with the (age-adjusted) size of the population. As a result no attempt is made to integrate the needs of populations or the service requirements to meet those needs in determining the optimal supply of providers. Instead, services respond to the workload preferences of providers. Using Evans' (1984) 'health care income-expenditure identity', developments that offer the prospect of reductions in health care expenditures, such as reduced needs and improved productivity, involve reductions in the aggregate income of providers, either through the use of fee-for-service remuneration systems or threats to the current levels of non-fee for service remunerated positions. Providers may therefore respond to maintain workloads and protect incomes and positions by identifying other 'things to do' for patients – and creating illusions of necessity (Evans, 1985).

Health workforce planning or 'demography gone wild'?

Estimating the future supply of providers involves quantifying the current stock of potential providers, future additions to and losses from that stock and the quantity of time for service production/delivery flowing from the stock (Birch *et al*., 2007). Aside from the careful identification and measurement of the determinants of these variables, estimating supply has provided few conceptual challenges.

Traditional methods for estimating future requirements for providers N_{t+1} have also been relatively straight forward, being determined by applying a provider-population ratio, $(N/P)^*$, to the estimated future size of the population, P_{t+1}. With the future population size being exogenous, future requirements are 'controlled' through $(N/P)^*$. In the simplest case the prevailing provider-population ratio is used and future requirements are driven entirely by the population size. Higher provider-population ratios may be used to respond to perceived shortages in providers (e.g., waiting times), or aging populations or to coincide with some external provider-population ratio (e.g. based on international recommendations). Nevertheless, the required number of providers is a fixed proportion of the population size. As levels of health or sickness (and by implication levels of need for health care) are absent from such models, two populations identical in size, but with different health profiles, would have the same provider requirements. Similarly, requirements would be independent of changes in population health over time. Only reductions in population size or lower provider-population ratios would lead to reductions in requirements for providers. There is no evidence of either condition ever having occurred in health workforce planning. So, what gives rise to the requirement for providers is the amount of people not the amount of sickness.

The traditional approach also assumes that the required number of providers is directly related to the size of the population (used as a proxy for the need for care) and that this relationship is constant over time and across communities. What providers do, how they do it and what they achieve by doing it, are implicitly assumed to be fixed. Under this approach the adoption of laser treatment and micro surgery in ophthalmology, although reducing the amount of time required by an ophthalmologist to provide treatment for patients with cataracts, does not affect the estimated required number of ophthalmologists.

We observe persistent claims of provider shortages because health workforce planning has been performed in isolation of service planning, allowing providers and professional bodies to expand services in order to meet their workload preferences. As the new or expanded services become the norm, demand (as opposed to need) per capita grows and more providers are required to meet this expanded demand. Therefore, although we might expect provider-population ratios to fall over time as the average health of the population and productivity in health care increase, we observe the opposite.

An integrated approach to workforce planning

To avoid these problems the conceptual basis of health workforce planning can be expanded to recognise that (1) need for health care is determined by the health of the population rather than simply its size, (2) the requirement for providers is derived from the requirement for services and (3) neither of these relationships is constant over time (Birch *et al*., 2007). The 'simple' demographic model suggests

$$N_{t+1} = (N/P)^* \times P_{t+1}$$

Because there is no objective basis for the provider-population ratio, $(N/P)^*$, we break this down into its constituent parts so that

$$N_{t+1} = (N/Q)_{t+1} \times (Q/H)_{t+1} \times (H/P)_{t+1} \times P_{t+1}$$

Where Q is the quantity of health care services to be delivered and H is the level of health in the population. Provider requirements are determined by four separate variables. *Demography* (P_{t+1}) remains a key determinant of requirements. However this is now translated into health needs through explicit consideration of *Epidemiology* (H/P), the average level and type of sickness in the population. No longer is the health profile of the population assumed fixed through time or across space. It represents the measurement of whatever oral health conditions the policy makers chose to include as warranting attention under the health care system. This does not exclude healthy individuals, because most health care systems include prevention and promotion as essential components. Thus the population being served is classified into different oral health states. A third determinant, *Level of Service* (Q/H), represents the planned level and mix of services to respond to the health profile of the population while *Productivity*, the inverse of (N/Q), translates the quantity of service requirements into requirements for each type of provider involved in the production of those services.

Incorporating need explicitly into the model is important in order to avoid the problems of demands being influenced by suppliers and not always reflecting needs as discussed above. Some needs may not present for services (unmet needs) but this matter can be addressed by dealing with problems of access to care discussed above.

Each element of the model is variable across space and time. Hence planning must incorporate changes occurring in all four elements, e.g., the reduction in dental disease among children, the increased productivity in ophthalmology etc. Moreover, each of these variables is potentially influenced by policies, although in the case of demography and epidemiology, potential policy levers are largely beyond the scope of health planners. Levels of service and productivity, however, are influenced by planners through decisions about what health care to deliver and how it is to be delivered. The methods for the economic evaluation for sustainable service planning presented above provide an evidence base for these decisions. In practice, however, such policy levers have been largely left to professional interests, through adopting recommendations of professional groups for service expansions and controlling the deployment of alternative providers.

Summary

In this paper we have explored the way economics contributes to understanding many of the problems encountered in promoting, protecting and restoring oral health in populations. If resources were not scarce, economics would have no role to play in addressing these problems. However, many problems we face arise directly from the limited resources within which policy makers operate. Failing to consider economics as part of any investigation concerning oral health care fails to reflect the reality in which the problem occurs. Dental research could benefit greatly from more informed, transparent and comprehensive debates about health economics and moving beyond cost-effectiveness-analysis. There is a substantial and growing literature on the economic aspects of oral health and health care that can be drawn upon (and added to) as we strive to 'do better' with whatever resources are made available to oral health.

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