RESEARCH PAPER

An Environmental Investment Decision Face to Face With Two Competing Systems: Sanitation and Healthcare

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Abstract

This study develops an economic relationship between public health and sanitation with the aim to provide arguments for environmental decisions on the most efficient allocation of available funds. The analysis addresses the specific case of illnesses originating from lack of sanitation. With data from a sample town in Brazil, it produces cost values for the competing systems of medical care and sewage collection, both of which being candidates to combat illnesses. The calculations assume that the existence of sanitary coverage is sufficient to eliminate illnesses, and are carried out with relative monetary units in order to make the procedure generally applicable. An illustrative numerical example shows, with the aid of opportunity cost accounting, how the relationship can be presented on a yearly basis to overcome the difficulty of comparing perpetual medical to sporadic sanitation expenditures. In conclusion, the proactive measure of investing in sanitation is shown to be economically preferable to the reactive provision of medical care for the kind of illnesses addressed.

Keywords: decision making, economics, environment, opportunity cost, public health, sanitation

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1. Introduction

A healthy society exhibits social, physical and mental well-being [1–3]. The literature has related physical well-being to sanitation with the general statements that one monetary unit invested in sanitation saves five monetary units of healthcare expenses [4]. One percent of sanitary service extension results in six percent of child death reduction [5]. Sanitation reduces human contact with insects who transmit deceases [6, 7]. A similar quantification is not available for mental well-being, but various studies show that infectious deceases affect the intellectual development of

youngsters and thus impair social progress [8–11]. Several of those deceases are a direct consequence of missing water and sewage treatment [3, 12–15]. Examples are diarrhea, cholera, hepatitis, malaria, dengue, and trachoma [16, 17]. The studies reveal the existence of an inverse relationship between sanitation and public health expenses. The better the services of sanitation, the lower the occurrences of deceases and the medical expenses for treating them [18]. This burdens public administrators with the responsibility of deciding where to invest scarce resources with the best return. Knowledge of the exact economic relationship between healthcare and sanitation will simplify decision making [19, 20]. Opportunity cost accounting comes into play as the need arises to determine for every investment, the cost of discarding the better alternative [21]. One might ask whether investments in public health can carry opportunity costs. The answer is "yes" whenever the investments are directed towards remediation instead of prevention. Any amount dedicated to prevention is five times as effective as that same amount dedicated to remediation, and sanitation is on the prevention side of the equation. The concepts of opportunity cost and real economic cost illustrate the situation with an example. Following the reasoning of Borges [4], stated above, an investor has two choices. Hypothetical option one is to invest 100 in healthcare and zero in sanitation. Hypothetical option two is to invest 16 in sanitation, which reduces healthcare costs by five times its value, or $5 \times 16 = 80$. The investment in healthcare drops to $100 - 80 = 20$. The total cost of option two is $20 + 16 = 36$. The opportunity cost of option one is $100 - 36 = 64$, which is the amount sacrificed by not choosing option two. The real economic cost of choosing option one is 164, which is the sum of the investment made and the savings sacrificed. This reasoning remains hypothetical because sanitary installations cannot be tailored to precise needs of health care [22]. They obey their own cost structures. The authors content that the opportunity cost of option one above drops to zero whenever the investment required to attend the population with sanitary infrastructure exceeds 200, no matter by how much healthcare costs are reduced. With healthcare costs equal to zero, the total cost of option two is $200 - 100 = 100$ and the opportunity cost of option one is $100 - 100 = 0$. The relationship of the two services is unidirectional. Investments in public healthcare produce no impact on sanitation, but investments in sanitation do have effects on public health. The present study pretends to quantify those effects.

The concept of health still evades a universal definition. It goes all the way from perfect social, physical and mental well-being to the absence of illness. This latter connotation is at the base of quantitative and statistical evaluations of the health situations of communities and the costs and effects of medical treatments. Preventive and corrective healthcare techniques, such as use of drugs and vaccines, are customarily evaluated with cost/benefit calculations. The choice of the most efficient techniques has resulted in reductions of infant mortality and increase of life expectance. Sanitation, or the lack of it, continues to influence the progress [23].

The concept of sanitation includes potable water supply, sewage and solid waste collection and treatment, and storm water drainage [24, 25], the existence of which constitutes environmental salubrity. In Brazil, the volume of sewage is approximately 80% of the volume of potable water consumption [14]. Both services, public healthcare and public sanitation, besides charging user fees in one way or other, derive their financial support from taxes paid by the population. There exists an intimate economic relationship between them, as they compete for the same tax money in quest for improving the health situation of a community. Any amount spent on one of the services is not available for the other one. Here resides the challenge of choosing the best investment, which is the subject of the present study. In addition, the challenge goes beyond the initial investment and includes constant monitoring of expenses and returns. As medical research leads to new treatment procedures and new drugs, ongoing cost/benefit analyses will guide the destination of tax money to investments that are more efficient. Sanitation infrastructure is a public asset. Ideally, all permanent urban buildings are connected to the public nets of water and sewage. There is no rivalry and no exclusivity [26]. The cost/benefit analysis of sanitary investments demands the correct evaluation of long-term benefits in order to compare them to the cost of construction and maintenance. Expenses with sanitary infrastructure are essentially sporadic, but they produce long-term benefits to the perpetual expenses with health care [25].

2. Objective

In order to contribute to the solution of the investment query, the present research pursues the objective to quantify the financial benefits in healthcare derived from investments in sanitation. It develops a calculation procedure readily adaptable to local situations. It uses data available from various public entities and applies them to a sample town in Brazil.

3. Methods

This study dwells on the economic relationship between public health care and sanitation. It investigates the specific cost items inherent in both services in a specific case study for the municipality of Monte Carmelo in the State of Minas Gerais, Brazil. The boundary conditions of the study are as follows.

On the healthcare side, only infectious illnesses originating from contact with sewage and leading to hospital internalizations are considered. They are listed in table 1. On the sanitation side, the study determined the number of residences at the sample location not served with sewage collection and treatment. It then produced a budget for providing this service to them. At the end, the argument stipulated that with complete sanitation infrastructure in place, the occurrence of the listed illnesses reduces to zero.

Table 1. Deceases related to lack of sanitation.

	Diarrhea
	Intoxication
	Intestinal inflammation
	Colitis
	Typhoid fever
	Cholera
	Yersiniosis
	Hepatitis
	Noroviruses
	Poliomyelitis
	Ascaridiosis
	Amoebas
	Giardiasis
	Schistosomiasis
	Cysticercosis

(Reference: [27])

The authors quantify the various cost items of healthcare services aided by information available from the data bank of the Brazilian Ministry of Health [28], for 113 municipalities situated in the State of Minas Gerais.

The source of data for sanitary installations is the National Information System on Sanitation [29], which provides cost items for collection and treatment of sewage and data on service coverage.

From the available data, a possible cash flow scheme is constructed for the provision of missing sanitary services that would eliminate the occurrence of infectious deceases within five years. This scheme is intended to guide the municipal decision makers in the allocation of funds. It spreads out the investment over five years to produce annual cash flows that can be compared to continuous medical expenditures. It shows opportunity costs that arise from restricting the allocation of funds to healthcare. It uses dimensionless monetary units to remain general and applicable to different local contexts.

The quantification of opportunities assists decision makers in arriving at investment choices [19]. As a simple illustration of choices within the healthcare system, consider the cost of saving patients' lives. If a certain amount of resources is applied to save one life, then the opportunity cost of the procedure refers to the number of lives that could have been saved with the same resources and the use of a more effective procedure, if it existed. In the present study, this means moving away from using medical resources to treat infectious deceases and towards improved sanitation in order to avoid the deceases. If funds are limited, the question is which investment option will produce the best possible long-term results [30].

Funds invested in healthcare will not be available for sanitation, and vice versa. The study attempts to guide the search for the most productive use of available funds.

Healthcare costs comprise direct, indirect and intangible items. The direct costs consist of medical and non-medical expenses. The medical expenses refer to personnel and use of installations. The non-medical expenses refer to transportation, nutrition and social assistance. The indirect costs measure the effect of illness on the economy in terms of days of work lost. The intangible costs are not quantifiable and refer to reduced quality of life resulting from pain and immobility. The authors quantify the various cost items of healthcare services.

In essence, investments in healthcare for treatment of deceases resulting from lack of sanitation are reactive measures. Investments in sanitation infrastructure target long-term benefits and thus are proactive. The installations imply in capital costs and operating costs during their life span. The study uses a time horizon for the cost/benefit analysis of investment choices, as proposed in [31]. The calculation procedure produces a monetary value of the liquid benefit of an investment, obtained by subtracting the total cost from the total benefit. Sanitation in this study refers to sewage collection and treatment. Income proceeds from user fees for the installations, and from savings in healthcare due to avoidance of sewage-derived deceases. Costs include installation and maintenance of the collection network and the treatment plant. Complete data on sewage collection coverage are available for the 113 municipalities cited earlier.

4. Results

The comparison of healthcare and sanitation costs has its limits. The benefits derived from sanitation are not limited to avoiding the occurrence of illnesses. Sanitation infrastructure has its own budget scheme. It cannot be tailored to strictly compensate for specific costs of healthcare services. The literature statement mentioned earlier [4] promised for every amount spent on sanitation a reduction of five times that amount in healthcare costs. Upon inverting the argument, this would allow for fixing the expenses with sanitation according to the healthcare costs to be eliminated. If healthcare were worth 100, investing 20 in sanitation should zero out that value. In practice, a minimum sanitation infrastructure might cost 200, with the potential to save 1000 in healthcare expenditures. The difficulty resides in comparing sporadic expenditures with sanitation to permanent expenditures with healthcare. The relationship may be treated only by spreading out the investment costs of sanitation over long time periods in order to simulate a continuous flow of cash as it occurs in healthcare services. In the numerical example shown above, if the 200 units of sanitation investment were obtained from a bank loan of ten years with yearly payments of 20, the resulting cash flow would attend to the desired

reduction in healthcare costs. The present study constructs an example of this type in order to live up to the promise of the title.

In this study, the monetary units refer to thousands of BRL (Brazilian currency), but they are maintained dimensionless in order to remain general. At the sample location, 84 yearly hospital internalizations were reported with an average duration of 3.91 days, for a total of 328.44 person-days per year. With the known daily expenses of 0, 274 monetary units per person-day at the location, the corresponding annual direct cost came to 90 monetary units. Each completed internalization required an extra three days of rest. The lost production was evaluated based on the local minimum monthly salary of 0.517 monetary units paid to the 84 patients during their 6.91 days of absence from work. The annual cost was 10 monetary units. The total healthcare cost due to illnesses derived from deficient sanitation was 90 + 10 = 100 per year, which is the reference for the relative cost values.

The situation of sewage collection was as follows. The sample town's 45772 inhabitants lived in 14953 residences. 2081 of the residences were not served by sewage collection. With the known cost of an individual sewage connection of 0.769 at the location, the investment required to connect the 2081 residences to the network came to 1600. The annual user fees collected from the 2081 new connections amount to 250. This represents a credit and can be used to repay the investment. As presented in the introduction, an investment economically preferable to the healthcare expenditures of 100 must not exceed 200. Consequently, the cost of 1600 minus the income from user fees has to be spread out over several years in order to be competitive and generate an opportunity cost for the option of healthcare.

The municipal administration is faced with the challenge of finding the most appropriate scheme for financing the sanitation outlay. This scheme may vary with local circumstances and opportunities. The following example illustrates one possible scheme. The amount of 1600 is borrowed from a bank at five percent yearly interest and equal yearly payments of capital. The payback period of the loan is five years. At the end of each year, the due payment consists of capital payback of 320 plus five percent interest on the remaining capital debt minus the credit from user fees. This scheme creates an immediate opportunity cost for the investment of 100 in healthcare. As an example, the first-year payment is $320 + 0.05 \times 1600 - 250 = 150$. With sanitation in place, healthcare costs are eliminated, and 100 can be credited to the investment in sanitation. The cost of sanitation is 150, and the cost of healthcare was 100. The opportunity cost of only investing in healthcare is $100 - (150 - 100) = 50$, which is the benefit sacrificed upon not investing in sanitation. Table 2 shows the evolution of payments and opportunity costs for the five years in question.

This hypothetical scheme illustrates how sanitation and healthcare expenditures may be creatively related. Investing only in healthcare represents a perpetual

Table 2. Payment sequence for a five-year loan of 1600 at 5% for sanitation infrastructure that eliminates healthcare costs derived from lack of sanitation.

Year	Payment of capital	Payment of interest 5% of remaining debt	Credit from user fees	Total expense	Opportunity cost of only investing in healthcare
1	320	80	250	150	50
2	320	64	250	134	66
3	320	48	250	118	82
4	320	32	250	102	98
5	320	16	250	86	114
Totals	1600	240	1250	590	410
6+	0	0	250	0	350

expenditure of 100 per year, whereas the investment in sanitation pays for itself in five years and burdens the healthcare option with an opportunity cost from the start.

What is the situation after five years? healthcare costs would have reached 500 and would continue permanently at 100 per year. Sanitation costs reached 590 and disappeared. The opportunity cost of the health care option during the five years is

$$500 - (590 - 500) = 410$$

and from there continues to be 350 per year indefinitely. The example shows a pragmatic comparison of investment strategies considering reduced healthcare costs as the only impact of sanitation. The argument may be expanded by including other impacts according to local situations. Using relative monetary values makes the approach general and independent of specific local costs. The opportunity cost concept facilitates comparisons of investment options. In the case at hand, healthcare without sanitation in the interval of five years costs 500, whereas sanitation costs 590 but eliminates the healthcare costs of 500. By opting for healthcare only, the investor sacrifices 410, which would be available for other purposes.

5. Discussion

The relationship between healthcare and sanitation has been treated in the literature from various points of view. They go all the way from the quality of water used within healthcare facilities [7, 22] to the ecological footprints of those facilities [20]. A specific case is the impact of poor sanitation infrastructure on the general

wellbeing of the population [3, 11, 23, 31]. The merit of the present research lies in presenting a case study in a typical municipality where the impact of sewage treatment on the occurrence of infectious deceases is quantified. It provides a spread sheet from which municipal administrators can read off and accompany the evolution of opportunity costs of investments in healthcare as sanitation infrastructure is improved.

The study contributed four new ideas to the comparison of economic costs of healthcare and sanitation. The first idea refers to attacking the time difference of the investments. healthcare is a perpetual process with perpetual expenditures, whereas sanitation infrastructure requires sporadic investments. Of necessity, the economic analysis has to be broken down into annual evaluations in order to allow for honest comparisons. The second idea applies opportunity cost accounting in order to facilitate investment decisions. The public administrator is usually faced with the need of choosing between two or more investment options to solve a single problem. The third idea defines a boundary condition for opportunity cost calculations. The study shows that an opportunity cost of an investment option only exists if the cost of an alternative option is less than double that of the original option. This latter idea led directly to the use of yearly evaluations adopted here. The fourth idea advocates the use of relative monetary values in the calculations. This procedure allows for direct comparisons of different local situations without the need for passing through currency transformations and inflation characteristics.

The study pragmatically reduced the comparison between healthcare and sanitation costs to provide a simple quantitative relationship. The costs considered for healthcare services are limited to illnesses derived from lack of sanitation and leading to hospital internalizations. The existence of sanitary infrastructure is considered sufficient to eliminate those illnesses. Within that scope, the study produced data on expenditures for medical care and for sanitary infrastructure corresponding to the sample town. To break down the sanitation investment into yearly parcels below twice the value of medical expenses, in this case they only had to be spread out over five years through a bank loan at five percent interest. This scheme created an opportunity cost for the option of only investing in medical care and thus indicated the investment in sanitation as the preferable choice.

6. Conclusion

The research develops an economic relationship between healthcare and sanitation. The scope of the analysis is limited to illnesses originating from lack of sanitation. Data from a sample town in Brazil are used to construct an illustrative example of costs involved and options of payment.

The example employs relative monetary values to make the procedure generally applicable.

The cost of healthcare for the indicated illnesses is assigned the reference value of 100. In the example, an opportunity cost is created for the healthcare expenses by spreading out the sanitation investment over five years.

The research contributes four new concepts to the procedure of comparing healthcare and sanitation expenditures.

Conflict of Interest

The authors declare no conflicts of interest.

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