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Health and the urban transition: Effects of household perceptions, illness, and environmental pollution on clean water investment

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Working Paper No. 2010/66

Health and the Urban Transition

Effects of Household Perceptions, Illness,
and Environmental Pollution on Clean Water
Investment

James H. Spencer*

June 2010

Abstract

Recent efforts to reinvigorate the connections between urban planning and health have usefully brought the field back to one of its original roles. Current research, however, has focused on industrialized cities, overlooking some of the important urbanization processes in poor countries. This paper describes an emerging ‘health transition’ and the importance of socio-ecological approaches to understanding new health challenges in the developing world and uses the empirical case of Vietnam to examine the development dilemma of new industrial health concerns associated with economic development. The paper summarizes original qualitative data suggesting that one of the main benefits and rationales of the system is the improvement in public health that it has promoted. Using a related original sample survey (n=200) from 2005, the paper then tests a set of hypotheses about the relationship between illness, connections to the new system, and the role of pollution of natural water sources in illness. Findings suggest that fears of illness, and in particular new forms of industrial illnesses, are growing with rapid development as old forms of acute water borne disease are of less concern.

Keywords: Water supply, perceptions, environmental health, transition, urbanization

JEL classification: H4, H7, Q5, P3

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1 Introduction

The rapid urbanization of Asia has reinvigorated the historic relationship between urban planning and health, which gave rise to the field with the publication of John Snow's map of cholera outbreaks in London (as recently described in Johnson 2006). In fact, one of the most direct connections between urban planning and health is the relationship between urban infrastructure, services and hygiene. While this issue has been adequately addressed in many industrialized cities, the rapid urbanization processes currently underway in much of Asia, Africa, and other parts of the developing world is a major challenge for planners, policymakers and the scholars that support their work.

A large body of empirically-focused planning literature exists on water infrastructure of rapidly developing cities, with appropriate attention to the complexities of multiple water user groups and sources (e.g., Crane 1994; Crane, Daniere and Harwood 1997; Zhang and Brown 2005; Gulyani, Talukdar, and Kariuki 2005; Spencer 2007b). Such studies share a focus on rapidly urbanizing areas that face a set of changing development dilemmas, but often the connection to public health is left implicit. Among public health scholars, one of the main concerns with rapid urban and economic development has been called a 'health transition', (Smith 1997), during which societies undergoing a rapid urban transition face a dangerous period. As economic opportunity, land use, and household demands intensify, traditional illnesses remain present, even as new ones emerge. The importance of such rapid socioeconomic, environmental, and biological change on the transformation of human risk has, in part, led interdisciplinary teams of scholars to focus on urbanization and the social ecology of disease emergence. Despite such concerns, empirical evidence on urban health transitions and rapidly evolving health challenges in fast-developing cities is limited to a small number of empirical cases (Costa et. al. 2005; Gubler 2002, 2004) and speculative frameworks (King et. al. 2006; Kapan et. al. 2006; Wilcox and Colwell 2005; Wilcox and Gubler 2005). This existing literature on the health transition regarding epidemic diseases such as dengue fever and avian influenza has begun to identify urbanization as a key factor in explaining public health outcomes, and in particular emerging and re-emerging infectious diseases. Less explored is the process through which concerns over basic and acute water borne diseases associated with basic hygiene to the newer health concerns associated with urbanization. The case of Vietnam is an excellent one for empirically examining this latter health transition because of its rapid economic reforms and urbanization processes that have drawn attention to a growing health transition challenge of industrialization, environmental pollution, and public health (DiGregorio, Rambo and Yanagisawa 2003; O'Rourke 2004).

2 Urban Vietnam's development dilemma

Despite making major gains in growth over the past decade, Vietnam remains a very poor country. According to World Bank indicators, Vietnam's average per capita income was US\$480 in 2003, on par with Mongolia, Uzbekistan, Sudan and Pakistan,

and \$10 below the average for sub-Saharan Africa (World Bank 2003),¹, a characteristic often forgotten in the excitement of such an economically dynamic context.

Despite this continuing poverty, Vietnam has experienced what seem to be important positive economic trends. From 1993 to 1998 general poverty was reduced from 58 per cent to 37 per cent, and for extreme—i.e. food scarcity—poverty from 25 per cent to 15 per cent. Along with these improvements came serious concerns, however, that the wellbeing of the poor was being threatened by decreasing access to public services of all kinds (Van Arkadie and Mallon 2003: 232). This threat was especially relevant because Vietnam's gains over the 1990s came not only through improved incomes but also through broader-based improvements in the quality of life. Despite its low GDP figures, Vietnam scored an impressive 112 out of 175 nations in the 2002 human development index (HDI, UNDP 2004), a broader-based measure that includes a wide range of public services including health, education and clean water. Vietnam's relatively high scores on the Human Development Index were, in large part, due to impressive gains in public health and education for a country with such low incomes.

This fact suggests that, as Asia urbanizes, changes in the way that public goods are ensured have disproportionate effect on the quality of life. In particular, the environmental contamination of natural resources, including clean water supply, has been one of Vietnam's central challenges in the *Doi Moi* period (DiGregorio, Rambo and Yanagisawa 2003; O'Rourke 2004). Others have usefully described how, under *Doi Moi*, water sources began to be degraded by agricultural chemicals, industrial waste, poor solid waste management, and urbanization (DiGregorio, Rambo and Yanagisawa 2003). It is not clear, however, that the household income improvements associated with *Doi Moi* (Van Arkadie and Mallon 2003) will provide local residents the opportunity to simply buy sufficient clean water individually.

This study examines how natural water resources have changed under *Doi Moi*, which is comprised of the linked processes of privatization, urbanization, and industrialization. Other studies have described how the policy affected the institutional structures providing public goods such as household water (DiGregorio, Rambo and Yanagisawa 2003; Fontenelle 2001), including the emergence of private environmental service businesses (DiGregorio, Rambo and Yanagisawa 2003) and quasi-public water companies (Spencer 2007a) in Vietnam. Beyond these descriptions of changing access to clean water, the unfolding process in Vietnam presents a unique opportunity to observe an emerging health transition through the lens of water supply and urban planning.

This paper describes how *Doi Moi* market reforms in Vietnam have influenced the delivery of domestic water in a particularly rapidly urbanizing area of Vietnam: the Mekong Delta. It reviews key elements driving the urbanization of Can Tho, one of the country's secondary cities, where the provision of clean water has become one of the main challenges resulting from economic growth. The following section uses qualitative

¹ The UNDP uses a different system for estimating GDP in calculating its human development index (HDI). The UNDP GDP per capita figure was US\$2,070 for 2001, a much higher figure than US\$480. In either case, though, the measure is comparable to low-income Central Asia and sub-Saharan Africa (GDP per capita of US\$1,831). The World Bank method is used here for calculating the measure of average income relative to other countries, however, because it adjusts for short-term fluctuations in exchange rates that can distort annual measures of GDP figures.

data from a rapid community appraisal in Can Tho, Vietnam, to show how the main stakeholders make the link between public health and a new water infrastructure system that provides piped household water. The third section describes a related, original survey conducted by the author and Vietnamese partners to test more systematically the role of health experiences and perception of pollution in households' decisions to invest in and connect to the new system or not. Section four presents the most relevant results, and is followed by some concluding thoughts, suggesting that for the renewed interest in urban planning and health to contribute towards solving the urbanization challenges in Asia, scholars and practitioners should further examine the intersection of water infrastructure in the context of changing demands and criteria for human consumption—especially as new migrants arrive in Asian cities like Can Tho across the world.

2.1 The changing demand for clean water supply in peri-urban Can Tho

In 2004, the Vietnamese National Assembly developed a strategy to turn Can Tho City into the fifth municipality in the country and invest in infrastructure that would turn it into a regional growth pole for the Mekong Delta. In effect, this strategy divorced the City of Can Tho from Can Tho province and significantly increased its governmental autonomy. This decision had several important material outcomes. First, it meant that the national government would prioritize the construction of major infrastructure for Can Tho City that would link it more directly to external markets. Thus, for example, an international airport was built, and the final section of a major highway linking Can Tho to Ho Chi Minh City, the country's most dynamic economic centre was opened in 2010. More locally, the plans meant that every ward in Can Tho was to have a market to facilitate local trading, and the City's population was planned to grow from about 1.3 million in 2004 to about 3.0 million by 2010.

This doubling of the size of the city in six years brought major changes to the ways in which residents secure clean water and sanitation. Can Tho's response to the challenge of in-migration and the pressures this placed on water supplies have been described generally elsewhere, and previous analysis has shown significant cross-use of the various piped, well, and natural sources of water in Can Tho. These findings suggest that the peri-urban areas of the city are currently undergoing a transitional period during which traditional sources and new sources compete for users (Spencer 2007a). This transitional period presents a dilemma for planners concerned with health, since access to the piped system itself—the 'pull' factor of new technology—is not the only concern for residents. 'Push' factors such as environmental pollution are also important in creating exponential demand for new water technologies, creating incentives for residents to switch from generally free traditional systems to costlier new ones.²

Preliminary estimates of the actual use of the new piped water system in Can Tho show moderate rates of connection at best. Only about 12 per cent of those eligible to connect to the system had done so by 2005, likely due to lack of funds, migration status, and the absence of a clear natural monopoly of the new piped system in an environment with several convenient options for securing water (Spencer 2007b). Such low usage rates

² Although publicly provided water is often less expensive than other sources, the development of Can Tho has been so rapid, and there is easy access to a major river, any water supply system must compete with abundant water of generally low quality.

call for a more in-depth analysis of the residents' motivations for connecting to the system, and suggest that natural water sources in the peri-urban areas of Can Tho have not yet become polluted enough to force the majority of residents to make the investments in piped household water. This 'push' factor, however, is a growing aspect of resident investment in and adoption of piped water supplies as the city urbanizes. The empirical part of this chapter explores the role that pollution, perceptions of pollution, and human health play in prioritising piped water within household budgeting decisions.

2.2 Local perceptions of the pollution of natural sources of water

In the spring of 2005, the author supervised a rapid community appraisal in two wards using the community-based water system working with Vietnamese colleagues at the Vien Khoa Hoc Xa Hoi.³ This appraisal was comprised of in-depth interviews with three main stakeholders in the new system: water users/residents, water station managers, and the water company management. Since there are four basic water source types in Can Tho—primary piped household water from a legal meter, piped water from a semi-legal meter, household pump well water, and river/canal water—interviewers discussed perceptions of water use with households using each of these four sources as their primary water supply. A review of all the references made during these interviews to the link between human health and water quality suggests a general concern with the link, but also some ambiguity as to why they hold these perceptions. In particular, personal experience of illness and disease, media education on the link between pollution and health, and awareness of general changes in water quality such as sediment level and smell were all used as rationales for switching to or wanting to switch to the new system. The following evidence was selected from a transcript of all the interviews and summarizes each time an informant discussed the relationship between human health and household water source.

Piped water meter users (legal and informal)

Residents who had connected to the new system through investing in a legal meter showed significant concern with all other water sources due to both industrial and agricultural/aquacultural pollution, but were equivocal in their perceptions of how it affected their health. Mr Nam, for example, stopped using river water in 1997 and dug a household well because the canal and river water 'had begun to smell bad'. He switched to the piped system in 2004, two years after it had become available in his area. He said that the 'water from the river definitely cannot be used [because of] the pollution from manufacturing wastewater and exhaust, not from agriculture or aquaculture'. He claims that he used to get diseases from the river water before, but now that has stopped. Similarly, Mr Tram said that he used to get cramps and scabies from using the river water, but thought that these problems might also have been caused by bad food or other bad socioeconomic conditions rather than the water. In general, though, he did not like to use the river water anymore because he was afraid of pesticides and animal waste.

A second user group is comprised of those who use piped water, but have not invested completely in the system by purchasing a meter from the water company and paying for the pipes leading up to the house. This group uses their own meter to connect informally to a neighbour's pipes, and then pays their neighbour (often a family member) based on

³ Southern Institute of Social Sciences.

usage. In general, this group shares the feelings of the legal meter user group, as evidenced by Mr Ba's statement that he 'connected [to his] neighbour's (a relative) meter in 2004 because the river was too polluted'.

Household pump well users

Since the late 1990s, many households have used their own private household wells since at that time they were concerned that the river and canal sources were becoming polluted. In general, this source seems to be less than satisfactory for users. Mr Hoang, for example, claimed that his well water was not so good, requiring at least 15 minutes for all the sediment to settle before it can be used. One example of the problems that his well presented was health. 'Last year my grandchildren came up from Kien Giang [province] and got sick from drinking my water. I also get rashes from swimming in the canal'. He is also afraid of using rainwater for drinking because he has heard through media sources that it has become too polluted, like the river water, through manufacturing activities over the past 4-5 years. Similarly, Mrs Mai is concerned with pollution of her well water. She leaves her pumped water for 10-15 days before use to let sediment settle, but claims that she never gets diarrhoea or cramps from the water, only headaches and fevers sometimes.

Natural source (rivers and canals) users

Not surprisingly, users of the natural sources believe that there is pollution of the canals and river, but have mixed feelings about how this pollution contributes to their health. Mrs Nhat, who plans to connect to the piped system if she can get enough money, claims that she never has any stomach problems or other diseases from using the river water, although some in her family have gotten rashes and scabies. She believes that the river water has become much more polluted in the past 5-7 years, although her family still discharges all of its waste directly into the canals near their house. Mr Em also believes that the river/canal water has become more polluted in recent years, saying that it smells very bad. He uses this source for daily household washing and for taking a bath, but believes that he sometimes gets scabies due to manufacturing discharges of wastewater into the river. Finally, Mr Xem primarily uses river water, but stopped drinking it when he started to get cramps from it even after it was boiled. He believes that these cramps and many other diseases are the result of aquaculture and industrial pollution of the natural sources.

Community water station managers

Managers of the new piped water infrastructure expressed significant concern with the quality of river/canal water and its effects on human health. Mr Son, for example, claims that 'water from [the river and canals] cannot be used [because] they are seriously polluted by industrial waste. [Industrial] air pollution may also be related to [industrial] water pollution, but both [kinds of industrial waste] are more serious than that from agriculture or aquaculture'. Similarly, Mr Truong adds that community members don't feel safe using the water, and that this was the result of media education on water issues. Both felt that having household piped water also contributed to their own psychological improvement because they felt safer about using it. In particular, they felt that this safety provided an important defence against what are seen to be serious threats of drinking and cooking with polluted water. Mr Son suspects there is a relationship between the industrial pollution and increased cancers in the ward, and also believes that the piped water has led to a large decrease in the incidence of scabies and

stomach cramps that he and his family used to get before they switched to piped water. He does admit, however, that it is hard to clearly make the case that piped water is the reason for this improvement.

Water company

An interview with the director of the company providing capital to and managing the water station masters suggests that human health is the primary outcome of this new system of piped water. Mr Loc admits that the company operates like a ‘business’, but believes it is very difficult to make money by providing water to the residents of Can Tho. He claims that his company generates more social benefits than economic ones by improving the general health situation, leading to a reduction in disease and illness.

3 Perceptions and reality: pollution, health and water

There is clearly much local concern about the link between pollution of natural sources and well water, and human health. However, there is no consensus on why some of those concerned residents have not switched to the new piped system. Although most informants not connecting cited limited economic resources as one of the primary factors, this explanation did not appear to be noticeably strong in empirical analysis (Spencer 2007b). Thus, the current study focuses on the role of pollution and human health—both demonstrated and perceived—in household decisions to connect to the system.

The three main ways that users seem to have made the link between health and water source are through personal experience of illnesses like stomach cramps, scabies/rash and fever, through media education about the links between industrial pollution and chronic illness such as cancers, and through the more tangible changes apparent in the water quality such as increasingly bad smells and sediment loads. It is clear from the in-depth interviews that each of these concerns *may* motivate residents to make a significant investment in the new piped system. What remains unclear is which actually *does*.

The primary hypothesis proposed here is that households experiencing a greater number of illnesses are more likely to switch to the new system. This basic relationship, however, can be difficult to pin down because of the difficulty in ascertaining how prevalent illness is within a household. Thus, the study also analyses *perceptions* of the causes of illness and perceptions of pollution levels of the various water sources in order to shed light on how important resident perceptions of danger associated with environmental contamination are in determining who switches on to the new piped system. This secondary set of hypotheses proposes that those who believe there is more environmental contamination of water sources, as well as those who believe that poor water quality is a major source of illness are both more likely to connect to the new system of piped water.

The first hypothesis that first-hand experience of illnesses that could be transmitted through contaminated water is tested using a partial correlation of reported frequency of recent illnesses with main water source, controlling for perceptions of family history of illnesses. The second set of hypotheses is tested by correlating perceptions of the causes of disease and perceptions of existing water pollution with the likelihood of households

switching to the piped system. Finally, since it is extremely difficult to determine residents' exposure to media campaigns promoting clean water, a third hypothesis can only determine the strength of the relationship between experiences of illness and fear of getting sick for each type of water source. Thus, the results present partial correlations of recent illness occurrence with resident perceptions of whether they become sick from using each of the water sources. These correlations are distinguished and presented separately for those who use that water source at least periodically, and those that use it as their main source in order to generally assess primary user perceptions from general community-wide perceptions.

3.1 Sample and procedure

The sample included 200 respondents equally distributed from two urban wards in Can Tho City. The wards were selected based on their proximity to the central business district of Can Tho, and the fact that they had, within the past three years, been redesignated from rural communes to urban wards. Within these two wards, researchers recruited participant households through a random sampling procedure, using the official ward roster as the sampling frame. Respondents were interviewed in a structured face-to-face format by research staff, and interviews lasted up to an hour. Participation was completely voluntarily and respondents were informed of their rights as a research participant, as well as compensated for their time. Where possible, the self-identified head of the household was interviewed and provided information on household characteristics. If the household head was not available, then the next senior member of the household provided the household-level information. Survey interviews and coding were conducted entirely in Vietnamese by staff from the Southern Institute of Social Sciences (SISS) and translated into English by staff from the University of Hawaii at Manoa Globalization Research Center (GRC).

3.2 Dependent variables

Main water source

Data were collected on the various sources of water for domestic use during the dry season and during the wet season. The closed-question format specified seven possible responses:

- i) 'from water supply station (private meter)',
- ii) 'from water supply station (but through other households)',
- iii) 'private well with manual/electric pump',
- iv) 'shared well with manual/electric pump',
- v) 'rain water',
- vi) 'natural sources (river, pond, canal)', and
- vii) 'others (specify)'.

In addition, households identified the 'source used the most' during both the dry and wet seasons. These responses, categorized from (i)-(vii), are the basis for the dependent variable on primary water supply. Because variation by this category did not differ much between the dry and wet season, except for the single response for 'rain water', only the data for the dry season were included. Importantly, no respondents identified

categories (ii) ‘from water supply station (but through other households)’, or (vii) ‘others (specify)’ as their primary water source. This is likely due to the fact that relatively few households connect to the piped water source in this way, as well as the fact that respondents may not want this information to be known.

Reported illness

Respondents were also asked whether they or anyone in their household had been affected by specific illnesses in the past four years or in the four years previous to that (excluding the year 2000, during which the water stations were constructed, ensuring a clear distinction between the period prior to and that subsequent to the new system). Each respondent was asked this question for diarrhoea, fever, stomach cramps, cholera, scabies or rashes, trachoma, dysentery, hepatitis a or e, or any other illness or symptom they believed was related to bad water. Respondents estimated the number of household members who had gotten sick from these illnesses and had these symptoms during each of the two periods. Because of the relatively low numbers for each separate illness or symptom, and because it is difficult to distinguish specific diagnoses of illness from general symptoms in the context of Can Tho, responses were combined into two variables of recent illness (2001-04) and historic illness (1996-99).

3.3 Independent variables

Resident opinions on sources of illness

The survey compiled information on each household head’s explanation of how water contributed to getting these illnesses and symptoms. They were asked ‘do you ever become sick from drinking...’ for each of the seven types of water source and answers were coded on a four-point scale with 0 = ‘don’t use this source’, 1 = ‘never get sick’, 2 = ‘rarely get sick’, 3 = ‘sometimes get sick’, 4 = ‘always get sick’.

Resident opinions on pollution of water sources

The household survey also collected information on the household head’s perception of pollution of the local natural environment and in particular the three main natural sources of water supply: river/canal water, rain water and ground water. Respondents were asked ‘what is the quality of rivers and canals’ in their areas, ‘...rain water’, ‘...ground water?’ Possible responses were 1 = ‘heavily polluted’, 2 = ‘some pollution’, 3 = ‘no pollution’, and 4 = ‘don’t know’.

Household income

Finally, the data file compiled information on each household member’s income, as well as net income from collective household and non-employment-related resources such as ‘cultivation/planting’, ‘animal husbandry, poultry raising, and aquaculture’, ‘retirement pension’, ‘early retirement subsidy’, ‘financial assistance (from government, social organizations)’, ‘assistance from relatives (within domestic and from overseas)’, ‘from house/land rental’, ‘loan interests (from credit/loan)’, ‘others’. These ten income sources were aggregated by household to provide a measure of the total capital available to each household, and represents a household’s ability to mobilize capital to connect to the new water system. Thus, a family with more capital availability is more likely to have the financial resources to allocate for purchase of a \$20 water meter.

4 Survey results

4.1 Frequency of recent illnesses and main source of water

The first question seeks to understand how residents' source of water is related to actual illness and disease. Table 1 provides general prevalence rates of reported illnesses known to be related to water quality, broken down by households' main source of water for the most recent period (2001 to 2004), and historically (1996-99). Although these reports can be subjective and based imperfectly on respondents' recollection of events, two points can be made about residents' recollection of illness. First, the argument that piped water users experience fewer illnesses than others is only partly correct. Although only 4.3 per cent have gotten diarrhoea recently and 8.7 per cent stomach cramps, these figures are higher than those for households that primarily use water from their own well, who exhibit figures of 2.6 per cent and 5.3 per cent respectively. Users of natural sources such as rivers, canals and ponds, have at least twice the rates of diarrhoea (8.7 per cent) although their experience of stomach cramps (8.7 per cent) is similar to the water station users. These findings moderately support the rationales used in the qualitative interviews suggesting that households on the new water system experience better health—at least on two of the main symptoms noted by informants. The third main symptom that informants complained of, scabies and rashes, do show clearly better health outcomes for piped water users. None reported being recently affected by

Table 1
Per cent of households experiencing of recent illness by main water source
(historic prevalence in parentheses)

	All water sources combined (n=200)	Water station (n=23)	Own pumped well (n=76)	Water pumped from neighbour's well (n=8)	Rain (n=1)	River and canal (n=92)
Diarrhoea	7% (4%)	4.3% (13%)	2.6% (3.9)	25% (-)	-	8.7% (2.2%)
Fever	4 (1)	8.7 (-)	- (1.3)	- (-)	-	2.2 (1.1)
Cramps	15 (3.5)	8.7 (8.7)	5.3 (1.3)	12.5 (-)	-	8.7 (4.3)
Cholera	2 (-)	- (-)	- (-)	- (-)	-	2.2 (-)
Scabies/rash	4 (3.5)	- (4.3)	1.3 (5.3)	12.5 (-)	-	2.2 (2.2)
Trachoma	4.5 (1.5)	- (4.3)	5.3 (1.3)	- (-)	-	5.4 (1.1)
Dysentery	- (-)	- (-)	- (-)	- (-)	-	- (-)
Hepatitis A or E	- (0.5)	- (-)	- (1.3)	- (-)	-	- (-)
Other illness	1.5 (0.5)	- (4.3)	1.3 (-)	- (-)	-	2.2 (-)
Partial correlation of recent illness with water source (controlling for previous illness and income; n=195)	N/a	-0.1321 (p=0.064)	-0.0891 (p=0.213)	0.1578 (p=0.027)	0.1064 (p=0.137)	0.0946 (p=0.186)

scabies, while 1.3 per cent of well users and 2.2 per cent of river water users reported recently being affected by scabies.

The second major point seen in the prevalence rates of symptoms by main water source are the changes in prevalence of diarrhoea, cramps and scabies over time from the first to the second period. Piped water users showed roughly a nine percentage point decrease in the prevalence of diarrhoea, while users of the canals and rivers reported about a six percentage point increase in diarrhoea occurrences. Those with their own pumped well showed a moderate 1.3 percentage point decrease. Thus, those who have connected to the station have gotten less diarrhoea since the system became available, while those relying on natural sources have gotten more. This record of improvement can also be made regarding scabies (a 4.3 percentage point decrease) for piped water users, although users of private wells also experienced this decline and the river users experienced no change, suggesting that the cause may not necessarily be these households' connection to the water system. On the other hand, the rate of stomach cramps, while remaining constant for piped water users, increased more than fourfold (from 1.3 per cent to 5.3 per cent) for well users and doubled for river water users (from 4.3 per cent to 8.7 per cent). Thus, although piped water users may not have experienced reduced stomach cramps, they may have been protected from a decline in the quality of water taken more directly from natural sources such as private wells and rivers and canals.

It is also interesting to note that users of water taken from neighbours' private wells reported extremely high incidences of diarrhoea, stomach cramps and scabies, especially in comparison with previous experience. However, due to the small number of respondents (8) it is difficult to know how generalizable this result is.

How generalizable are the findings of generally improved health for piped water users and a decline for users of river and canal water? Table 1 also presents partial correlation coefficients of the prevalence of recent illness with main type of water source, controlling for the prevalence of water-related illnesses reported by a household in the previous period, as well as for total household income. Because the sample sizes are relatively small and statistical significance is difficult to achieve, the reported coefficients include p-values to give a sense of overall reliability. Thus, we can be roughly 93.6 per cent sure ($p=0.064$) that households that have connected to the piped water system experience less water-related illness than users of the various other sources even when income and the household's overall tendency to report sickness are taken into account. Such a strong claim cannot be made that households drawing water mainly through a private well have experienced a reduction in the occurrence of water illnesses ($p=0.213$). Similarly, one cannot say that users of natural sources have experienced more water-related health problems in the most recent five-year period than in the past five-year period. These latter two findings are not surprising, given that there was no systematic change in these households' main water sources.

4.2 Perceptions of the causes of disease, opinions on existing water pollution, and likelihood of households switching to the piped system

The analysis of illness and likelihood of switching to the new piped water system suggests that there are moderate relationships between improved health outcomes and household connection to the piped water system. It is difficult, however, to say conclusively whether those using private wells have lower rates of water-related illness

or those using natural sources have higher rates. Given the relatively low incidence of the related symptoms of water-related illness, an examination of how households believe they get sick can be a useful measure of why they choose the source of water they do. Table 2 tabulates the answers to opinion questions on whether respondents get sick from using different types of water. These questions were asked of all users (whether used as a primary source or a secondary source) for each of the main types.

Results suggest that residents do not believe that bad water sources are a major cause of sickness. According to users, the most reliable source of drinking water is ‘other’ or bottled water, with rain water seen to be a similarly reliable source with 98 per cent of respondents claiming that they never get sick from using rain water. Similarly, piped water and well water were seen not to be major sources of illness, and only 17 per cent of respondents using canal water claimed that it ever led to sickness. Thus, responding households do not believe that the kinds of household water they use at any level is a main source of illness. Asked more generally whether they ever became sick from drinking or bathing in polluted water, only 13 per cent claimed that they did. These low values for reported illness from using various water sources are most likely the result of households generally being careful about where they get their household water, and help to explain why the rates of recent and historical illness reported in the previous section are relatively low. If households carefully choose which source to use for what purposes, then they can minimize the incidence of illness, which results in high response rates for never getting sick from using the various sources of water for drinking or bathing.

This finding that households are strategic about their use of the various sources regarding health safety, however, does not provide an assessment of the quality and pollution of the various natural water sources available for use in ward. Thus, Table 3 tabulates respondents’ opinions on the pollution of the three natural sources of water that they all are able to qualitatively observe and assess from the point of view of a community resident rather than a user: canal water, rain water, and ground water. Generally, residents believe that canal water is heavily polluted. 29 per cent said it was heavily polluted and over 56 per cent said it was somewhat polluted. These figures are much lower for rain water pollution, 58.5 per cent of whom said they believed that rain water was not polluted. Similarly, 41 per cent said they believed ground water was not polluted. What is interesting, however, is the relationship between these perceptions and respondents’ likelihood of switching to the new piped system, presumably to avoid the dangers of increasing pollution. While it is difficult to conclusively say that perceptions

Table 2
User household opinions on the source of illness

	Never	Rarely	Sometimes	Always
Ever become sick from drinking piped water (n=24)	96%	–	4	–
Private well? (n=75)	97%	3		
Water from shared well? (n=12)	92%	8		
Rain water? (n=100)	98%	2		
Water from rivers/canals? (n=121)	83%	7	7	2
Water from other sources? (n=56)	100%			
Ever become sick from drinking/bathing polluted water? (n=200)	87% = no; 13% = yes			

of higher canal pollution are significantly related to switching to the new system, it is clear that the greater a respondent's perception of rain water pollution, the more likely they are to switch to the new piped system. Thus, even though there are relatively fewer who think that rain water is polluted, those that do take action at a much higher rate than do those perceiving the pollution of rivers and canals.

Table 3
Household opinions on the pollution of river/canal water and rain water (n=200)

	Nearest canal water	Rain water	Ground water
Heavily polluted	29.0%	3.0%	2.5%
Somewhat polluted	56.5	13.5	22.0
Not polluted	12.5	58.5	41.5
Don't know	2.0	25.0	34.0
Correlation of opinion on source pollution and connection to piped system (excludes don't know responses)	-0.104 (p=0.147; n=196)	-0.159 (p=0.052; n=152)	0.030 (p=0.736; n=132)

4.3 Recent illness occurrence and resident perceptions of whether they become sick from using each of the water sources

The previous statistical analysis found that residents did not link illness with their own use of various water sources. In addition, it found that they perceived a lot of pollution in the canals and moderate amounts in rain and ground water, but that the perceptions of polluted rainwater had a much greater impact on decisions to switch to the new piped water system. To what degree are these perceptions of pollution and the perceived link between the use of various water sources and illness related to personal experience with water related illnesses?

Table 4 presents partial correlation coefficients of resident opinions on the health safety of each water source type with degree of recent illness, controlling for past illnesses. Thus, positive coefficients mean that the more a resident has gotten sick recently, the greater they believe that a given water source is unhealthy. Inversely, a negative coefficient signifies that the more a resident has gotten ill recently, the more strongly he or she feels that a given water source is healthy. The correlations were run for both the population as a whole, and for the subgroup of users who use—at any level—the water source in question. Thus, it estimates the relationship for the community as a whole and for those who have at least some experience with that water source.

Table 4 shows that residents who have gotten sick recently believe that river and canal water is unsafe to use. This strong relationship amongst households that regularly use this source of water holds true even when the larger community that includes many non-users is taken into account. Since 86 respondents in the survey did not regularly use river or canal water, it is clear that recent experience with some kind of water-related illness is associated—for both users of river water and non-users—with stronger health concerns with this source of water.

It is also clear that community residents who have recently experienced water-related illness believe more strongly that rain water is an unhealthy source of domestic water. However, this belief may result from many community members not regularly using this source of water. When only the regular users of rain water were assessed, there was

no statistically significant relationship, at the 0.05 level, between recent illness and concern with rain water. Although this difference may be the result of a small sample size, it may just as likely be due to the users not attributing recent illnesses to their use of rainwater.

Although neither the community nor the user group perception of the relationship between recent illness and safety of the piped water showed a statistically significant relationship, an examination of the p-values suggests that there is indeed a difference between the perceptions of the users and those of the larger community. We can be 91.4 per cent sure that, in the larger community, the more a respondent has been ill in recent years, the stronger his or her opinion that the piped water is safe to use. However, we are almost certain that this association between recent illness and strength of confidence in the safety of piped water is—for piped water users—due to chance. Again, this result may be due to the relatively small numbers of piped water users ($n=20$), but it also may be due to a realization amongst piped water users that the system cannot entirely eliminate water-related illnesses.

Finally, those who have experienced higher levels of recent illness believed more strongly that obtaining water from other households' wells is not a safe alternative, a finding that was strong among both users themselves ($p=0.053$) and the larger community ($p=0.030$). This finding suggests that the informal sharing arrangements surrounding private wells may actually constitute a small market in inferior quality water.

In general, one can say with certainty that residents who have experienced recent illnesses are more likely to express concern with polluted water in general. This significant finding does suggest that health, although perhaps not an immediate improvement for those transferring to the new piped system, is certainly a strong motivator for households to invest in the new system.

Table 4
Correlation of perceptions of water sources by levels of illness
(controlling for previous illnesses)

Get sick from this source of water?	User opinion		Community opinion	
Water station	-0.0591	($p=0.794$; $n=20$)	-0.1224	($p=0.086$; $n=196$)
Own pumped well water	0.0075	($p=0.949$; $n=73$)	-0.1093	($p=0.125$; $n=196$)
Water pumped from neighbour's well	0.625	($p=0.053$; $n=8$)	0.1543	($p=0.030$; $n=196$)
Rain	0.0668	($p=0.682$; $n=38$)	0.1563	($p=0.028$; $n=196$)
River and canal	0.4218	($p=0.000$; $n=110$)	0.3716	($p=0.000$; $n=196$)
Other	0.0206	($p=0.884$; $n=51$)	-0.061	($p=0.393$; $n=196$)
Polluted water in general	N/a		-0.3438	($p=0.000$; $n=196$)

5 Concluding thoughts: an urban health transition in environmental pollution and health concerns

The case of water provision in Can Tho is one reflecting larger processes of rapid urbanization and consequent development dilemmas set in motion by *Doi Moi* in Vietnam. In particular, an urban transition has led to relatively new health concerns of

rapid development. This transition is exacerbated by increased pressure on traditional public services and presents a serious challenge to the state in its historic role of providing public services to a population demanding ever more in quality and quantity. Few studies have focused on these changing perceptions inherent to urbanization in Asia and elsewhere in the developing world.

This examination of the relationship between a new piped water system in Vietnam and resident health assesses the role that human health and perceptions of environmental pollution play in motivating residents to invest in improved water infrastructure systems. Although qualitative data strongly suggested that health and environmental pollution were the primary motivations, statistical analysis suggests more precisely that it is the *fear* of illness and its potential effects on human health rather than actual experiences of illness that motivates users to connect to the piped water system. These motivations should be distinguished from clear health problems experienced by users of those sources seen to be increasingly polluted. Thus, it is the perception and education of residents about an emerging health transition that drive investment in the new system.

The first set of questions assessed which water users were more healthy. Generally, piped water seemed to have lower prevalences of diarrhoea, scabies and stomach cramps, but one cannot say that natural source users (rivers and canals) have demonstrably experienced poorer health, as suggested in the interviews, due to a deterioration in water quality over the past five years. Thus, the study continues on to examine the relationship between experienced disease, water quality and environmental pollution, and to what degree these factors are related to residents' connecting to the new water system.

The paper's second finding is that, contrary to the suggestions of informants, especially of the water station managers and the water company, poor health is not necessarily seen to be associated with any of the water sources in an absolute sense, although users of canal and river water have somewhat higher associations between canal water and illness. Even for this source, however, the connection was made by only about 20 per cent of the respondents. Thus, residents do not seem to perceive a clear connection between the use of various sources and their health. This somewhat surprising finding suggests that users are cognizant of the health risks posed by different sources and make necessary adjustments to which sources they consume in which ways. Thus, water source choices may be due to issues of convenience—although of a quite serious nature—rather than to illness. This is consistent with the finding that opinions on the pollution of canals and ground water sources are not necessarily motivators for residents to switch to the new system. However, opinions on rain pollution were seen to be of much greater cause for concern and clearly associated with switching to the piped system—an important point to be addressed shortly. This finding on canal and groundwater pollution brings up the question of how much of a motivator previous experience of illness is in determining water safety of various sources.

The third finding is that there is a significant relationship between recent experience of illness and the perception that piped water is good to use. A relationship not necessarily true for the piped water users themselves. Thus, it seems that non-piped-water users have high hopes that piped water may help with improved health, while existing users may see that the system cannot be a panacea for all illness. Finally, all community respondents clearly had concerns with the safety of using a neighbour's well, with a strong implication about informal sharing arrangements. Even though few actually get

water in this way, many believe this kind of arrangement is dangerous, perhaps because water shared by neighbours is known to be of inferior quality.

Overall, the findings help to explain why there are such low rates of takeup (Spencer 2007b) on connecting to the new piped water system in Can Tho, and extend the explanation of how pollution might affect residents' motivations for connecting. More specifically, although there is clearly an increasing concern with pollution associated with denser settlement and industrial economies, residents have been able to manage so far the acute threats of that pollution (e.g., traditional water borne diseases such as cholera) by making careful choices about what they use the various sources of water for. Rather than the experience of health problems associated with polluted water, it is the fear of pollution, and especially pollution seen to be most closely related to industrial development such as the pollution of rain water through air pollution that seems to be most closely related to resident connections to the system. In this light, it is likely that media education is the most relevant factor for motivating residents to connect, and these efforts should be expanded.

These findings on the health and health perceptions associated with various water sources point out the need to better understand the changing health concerns associated with rapid urbanization. As Asia's cities grow rapidly in population densities, and public investments such as water supply struggle to keep up, residents likely shift their priorities about what constitutes clean water, even as they make important decision about what sources to use safely and when. These new water supply concerns that are increasingly evident in Can Tho are likely the case for other rapidly urbanizing regions of the world that increasingly feel the paradox of new health concerns arising from rapid economic development.

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