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Reframing Undernutrition: Faecally-Transmitted Infections and the 5 As

Robert Chambers and Gregor von Medeazza
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Robert Chambers and Gregor von Medeazza

Summary

The dominant nutrition discourse concerns access to adequate food and its quality. It now includes food security, food rights and justice, governance and agriculture. Despite many initiatives to assure food access, and growing economies, high levels of undernutrition persist in much of Asia. It is increasingly suggested that much of this 'Asian enigma' can now be explained by open defecation (OD) combined with population density. However, the insight that 'shit stunts' remains a widespread blind spot. The persistence of this blind spot can in part be explained by factors which are institutional, psychological and professional. Reductionist focus on the diarrhoeas, which are serious, dramatic, visible and measurable, has led to the relative neglect of many other often subclinical and continuously debilitating faecally-transmitted infections (FTIs) including environmental enteropathy (EE), other intestinal infections, and parasites. These are harder to measure but together affect nutrition much more: the diarrhoeas are only the tip of the much larger sub-clinical iceberg. How OD and FTIs, poverty and undernutrition reinforce each other is illustrated in this paper by looking at the case of India, which has about 60 per cent of the OD in the world, around a third of the undernourished children, and approximately a third of the people living in poverty. Through OD, FTIs and in other ways, lack of sanitation leads to losses, which may be estimated, in the range of 1 to 7 per cent of GDP in various countries.

To reframe undernutrition for a better balance of understanding and interventions, we propose two inclusive concepts: the FTIs and the 5 As. The first two As – availability and access – are oral, about food intake, while the last three As – absorption, antibodies and allopathogens – are novel categories, anal and internal, about FTIs and what happens inside the body. These concepts have implications for research, professional teaching and training, and policy and practice. While other countries make rapid progress towards becoming open-defecation free, India remains obstinately stuck, making undernutrition in India one of the great human challenges of the twenty first century.

The concepts of FTIs and the 5 As reframe more inclusively how undernutrition is perceived, described and analysed. Our hope is that this reframing will contribute however modestly to a cleaner, healthier and happier world in which all children and adults are well-nourished and can grow and live to their full potential.

Keywords: faecally-transmitted infections; India; open defecation; professionalism; research; sanitation; stunting; undernutrition.

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Acronyms and abbreviations

DFID	Department for International Development
DHS	Demographic and Health Survey
EE	environmental enteropathy
FAO	Food and Agriculture Organization
FTI	Faecally-transmitted infection
ICDDR,B	International Centre for Diarrhoeal Disease Research, Bangladesh
ICDS	Integrated Child Development Services
IQ	Intelligence Quotient
LSHTM	London School of Hygiene and Tropical Medicine
NTD	Neglected Tropical Disease
TSC	Total Sanitation Campaign
WASH	Water, sanitation and hygiene
WHO	World Health Organization
WSP	The World Bank Water and Sanitation Program

1 Origins, purpose, scope, limitations

This Working Paper originates from the provocation of Jean Humphrey's seminal Research Note in *The Lancet* (Humphrey 2009). In that note she presented evidence that tropical (now called environmental) enteropathy (EE)[1] could account for much more child undernutrition than the diarrhoeas which were only the tip of an iceberg. EE inhibits growth linked to the ingestion of faecal matter, but it is a largely subclinical condition. Because EE is so difficult and expensive to measure and relevant 'rigorous' research takes so long to produce results, EE has been, and still often is, described as a 'hypothesis' by stringently correct medical researchers. Recent research (e.g. Spears 2013, 2014a and b) has led to the emerging conclusion that in many environments a half to two thirds of undernutrition can be attributed to open defecation and faecally-transmitted infections (FTIs), with EE the most significant of many.

We use the term FTIs to be inclusive of all infections that are faecally-transmitted. This is to avoid two common exclusions. The first is 'faecal-oral' which excludes parasite pathways through the skin as with hookworm and schistosomiasis (see e.g. Mara *et al.* 2011). The second is 'water-borne' which excludes infections such as hookworm, trachoma (WHO 2013a) and tapeworms, which are not water-borne. FTIs include but are not limited to the diarrhoeas (such as cholera, shigellosis, rotavirus, cryptosporidiosis, and campylobacter), intestinal parasites (such as giardia, amoebiasis, ascaris, hookworm, trichuris and tapeworms), EE, and other conditions such as Hepatitis A, B and E, typhoid fever, liverfluke, poliomyelitis and other enteroviruses, neurocysticercosis, schistosomiasis, trachoma, and other zoonoses. More details and references on the FTIs are given later in this paper.

Building on two India-focused publications – 'Sanitation and Stunting in India: Undernutrition's Blind Spot' (Chambers and Medeazza 2013) and 'Undernutrition's Blind Spot: A Review of Faecally-Transmitted Infections in India' (Chambers and Medeazza forthcoming 2014) and on more recent research published since those were written, the purpose of this Working Paper is to explore the issues in a wider perspective and context. While the scope is worldwide, the major focus in this paper is on India which has about a third of the stunted children in the world, around 60 per cent of the world's open defecation, and a wealth of very recent relevant research.

Against this background, we have three purposes: to examine how open defecation, lack of sanitation and hygiene, and FTIs contribute to stunting; to shed light on why this has been a blind spot; and to present new inclusive categories and concepts (the FTIs, and the 5 As) for reframing how undernutrition is perceived, analysed and acted on. We conclude by exploring practical implications of this reframing for research, teaching and training, as well as policy and practice.

2 Empirical basis and evidence

Much of the evidence for this Working Paper comes from what the literature we have examined covers and concludes, what it does not cover, and recent and emerging research.

[1] An August 2014 a useful overview of the state of knowledge (Crane *et al.* 2014) uses the term Environmental Enteric Dysfunction.

We carried out a literature review to identify relevant evidence related to the impact of water, sanitation and hygiene (WASH) interventions on reducing diarrheal diseases and other FTIs and through them on reducing undernutrition. Between June 2012 and May 2014, a key-word search was carried out of some 250 English-language studies published in the past 10 years in international peer reviewed journals and United Nations publications. About a third of these are referred to in this Working Paper. Some earlier work was included to shed historical light on the 'blind spot'. We also hand searched reference lists of key articles for additional relevant material and consulted internal UNICEF literature reviews offering overviews of the topics related to WASH and nutrition. For broader coverage, we also searched grey literature and conference proceedings.

Publications and websites were consulted and/or colleagues contacted from the following organisations (in alphabetic order): Center for Disease Control, Children Without Worms, Department for International Development (DFID), Food and Agriculture Organization (FAO), IRC International Water and Sanitation Centre, Institute for Development Studies (IDS) (University of Sussex, UK), International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B), London School of Hygiene and Tropical Medicine (LSHTM), Public-Private Partnership for Handwashing with Soap, Rice Institute, Stockholm International Water Institute (SIWI), UNICEF, USAID, WaterAid, the Water, Engineering and Development Centre (WEDC, Loughborough University, UK), World Bank, the World Bank Water and Sanitation Program (WSP), the World Health Organization (WHO). We contacted subject experts and study authors, who provided additional information and further relevant references.

Throughout we looked for gaps and inconsistencies in the reviewed body of knowledge. In the light of recent research, we focused particularly on light shed on the 'blind spot' of links between open defecation and undernutrition. Recent research and the literature review also informed our development of the conceptual framework of the 5As (see below pp24-26) and contributed to cross-disciplinary recognition of the significance of FTIs and the identification of gaps for research.

3 The dominant nutritional discourse

The scale of undernutrition in the world, and its appalling and irreversible effects on children, especially in the first thousand days, need no emphasis. Eliminating undernutrition has to be an overarching ambition for humankind, in parallel with the eradication of poverty and the reduction of inequalities. In this paper, while we critically examine dominant professional norms, values, incentives, methods and mindsets, nothing that follows should be allowed to weaken the nutrition-related commitments to improving the quantity, quality and reliability of food that children and others are able to consume. That has to remain a high priority.

The overwhelmingly dominant discourse of nutrition and undernutrition has been and remains related to food intake and assuring that enough food, of good quality is reliably and continuously available to infants, children and adults. The mindset is fixed and focused on direct delivery. Major international efforts focus on improving and assuring food security for poor, marginalised and isolated people. Journal articles and books concerned with hunger and nutrition have repeatedly focused on quantity and quality of food, feeding programmes and micronutrients, and in recent years, issues of governance, rights and justice, often to the total or near-total neglect of sanitation, hygiene and FTIs, or only a passing reference (e.g. Paul *et al.* 2011).

The spread of the span of relevance to include governance, food justice, food security and agriculture can be illustrated by a series of *IDS Bulletins*: 'Lifting the Curse: Overcoming Persistent Undernutrition in India' (IDS 2009); 'Standing on the Threshold: Food Justice in India' (IDS 2012) including articles by N.C. Saxena (2012b) on 'Hunger and Malnutrition in India' and Harsh Mander (2012) on 'Food from the Courts: the Indian Experience'; and 'Seeing the Unseen: Breaking the Logjam of Undernutrition in Pakistan' (IDS 2013) which includes assessment of selected interventions. However, the spread of the span of relevance in these Bulletins does not include WASH, to which no article is devoted. At best it is mentioned briefly in passing but not followed up; and a recent study of Maharashtra's decline in child stunting (Haddad *et al.* 2014) does not take account of the substantial reduction in the number of people defecating in the open per square kilometre – the density of open defecation – in Maharashtra between 2001 and 2011, while most people in India lived in districts where it increased (Spears 2014a).

At the same time, the significance of WASH and in particular of open defecation (OD) has increasingly been recognised. The seminal publication has been Jean Humphrey's Research Note 'Child Undernutrition, Tropical Enteropathy, Toilets and Handwashing' in *The Lancet* (Humphrey 2009). Since then, among increasing numbers of researchers in particular (for instance in the SHARE Consortium, including the LSHTM and the ICDDR,B), perceptions and priorities have changed. In parallel, sanitation and hygiene have gradually but very slowly appeared increasingly in nutrition-related policy statements. As early as 2010, WASH was mentioned in DFID's undernutrition strategy paper (DFID 2010). In the nutrition literature more broadly, the relationships between sanitation, hygiene and FTIs have been recognised, reviewed and highlighted (see for instance Prüss-Üstün *et al.* 2014; Loevinsohn *et al.* 2014; Chambers and von Medeazza 2013; Dangour *et al.* 2013; Spears 2012, 2013; Bartram and Cairncross 2011).

While understanding has been moving towards recognising the huge significance of environmental factors, especially FTIs, many publications continue to largely overlook them. At best, they bow towards sanitation and hygiene, and then continue with business as usual. Often, the overwhelming emphasis is on nutritional intake, including micronutrients – Vitamin A, iodine, zinc and iron. Blindness is often solely associated with Vitamin A deficiency, while faecally-transmitted trachoma is mostly absent, despite it affecting about 80 million people globally (Fenwick 2012), and causing visual impairment of about 2.2 million people, of whom 1.2 million are irreversibly blind (WHO 2013a). Similarly, attention to intestinal parasites is often focused solely on deworming. The fact is that the significance of WASH remains too often a blind spot, largely unrecognised and not acted on.

4 Persistent undernutrition: the Asian enigma

In the dominant discourse, the persistence of undernutrition despite large-scale feeding programmes and other interventions has been widely regarded as difficult to explain, especially in Asia.

Consider the case of India. Deaton and Dreze (2009) in their magisterial overview 'Food and Nutrition in India: Facts and Interpretations' observed that '[…]the nutrition situation in India is full of 'puzzles' They pointed out that 'the adult height of Indians – an indicator of nutrition and disease in childhood and adolescence – has improved more slowly than has been the case in other countries'. In the 1990s, 52 per cent of children in India were stunted,[2] compared with 40 per cent in sub-Saharan Africa, 34 per cent in China and 18 per cent in Sri

[2] 'Stunting' refers to the reduced growth rate in human development (low height for age), and is an indicator of chronic undernutrition.

Lanka (UNICEF 2013). As per the latest reliable available national-level estimates for India, in 2005-2006 48 per cent of children under five years of age were stunted and 43 per cent were underweight (NFHS-3 2007). The proportion of children who were severely undernourished was also high, with 24 per cent according to height-for-age and 16 per cent according to weight-for-age. Wasting[3] was also serious and affected 20 per cent of children under five years of age (NFHS-3 2007). Nor does this appear to be a matter of out of date statistics, India having had no Demographic and Health Survey (DHS) survey since 2006. The pattern is confirmed by recent data for 100 districts in nine states selected from the bottom of a child development index. These are likely to be worst cases, but would drag down the national average sharply with the finding that 59 per cent of children under five in those districts were stunted, and of these about half were severely stunted (Naandi Foundation 2012).

Other Asian countries, except for Bangladesh (see below), show similar patterns. In Pakistan, stunting increased in the past three decades from 42 per cent in 1985 to 44 in 2011. With population increase this doubled the number of stunted children under five over the same period from 6.385 to 11.8 million. Floods were a factor but this deterioration occurred despite respectable economic growth (Bhutta *et al.* 2013; Balagamwala and Gazdar 2013). The obstinate resilience of undernutrition levels to come down much in Indonesia is another example (pers. comm. Lawrence Haddad).

The puzzle has been described as 'the Asian enigma': it has occurred despite substantial economic growth. Remarkably, children in India are shorter on average than children in Africa who are poorer on average (Ramalingaswami *et al.*1996). Most recently, a 2014 study of 121 Demographic and Health Surveys from 36 low-income and middle-income countries found 'At the country level no association… between average changes in the prevalence of child undernutrition outcomes and average growth per head GDP' (Vollmer *et al.* 2014). Of the 36 countries India had the highest rate of underweight children (42 per cent), this despite decades of sustained growth of GDP.

5 Open defecation and undernutrition: the enigma resolved

The enigma has now been largely or entirely resolved, and the differences explained, by OD and associated unhygienic conditions and practices. Or, the use the stark aphorism, the recognition that 'shit[4] stunts'.

Research by Spears (2013, 2014b) based on 140 Demographic and Health Surveys, has found that open defecation accounts for much of the excess stunting in India. Other studies also show an association of height with sanitation and of stunting with a lack of sanitation and with open defecation (Ghosh *et al.* 2014; Hammer and Spears 2013; Spears 2012; Fink *et al.* 2011). Recent research in Cambodia (Kov *et al.* 2013), and in Lao PDR and Vietnam (Quattri and Smets 2014), after controlling for confounding variables, has found strong associations between stunting and a combination of open defecation and unimproved latrines (and no association was found between improved

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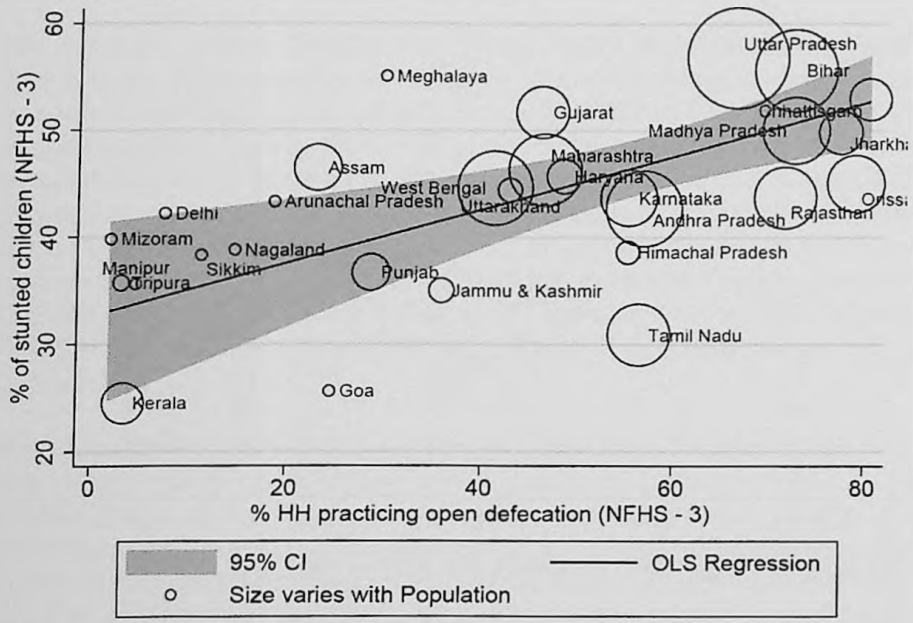
3 'Wasted' refers to the process by which a debilitating disease causes muscle and fat tissue to 'waste' away (weight for height), and is regarded as acute undernutrition.

4 'Shit' has not been a word much used in professional circles but is in the title of a significant academic book *Shit Matters* (Mehta and Movik 2011) and has appeared five times in a British House of Commons Report (House of Commons 2011). It is used in Community-Led Total Sanitation (CLTS) practice to provoke realism ('facing the shit'), disgust and action for dignity, self-respect and wellbeing.

latrines and height when neighbours were practising open defecation). In rural Vietnam in parallel with a decline in open defecation from 44 per cent in 1990 to 3 per cent in 2012, stunting declined from 42 per cent in 2000 to 25 per cent in 2010/11. In mountainous areas in Vietnam, five-year old children have been found to be 3.7cm taller in communities where everyone practises improved sanitation than in communities where open defecation and unimproved sanitation prevail (WSP 2014).

At a more general level there are correlations between the countries around the world which have the highest numbers of open defecators, the highest numbers of under five deaths and the largest proportions of stunted children: out of the 20 countries with the most open defecators, 17 have stunting rates of 35 per cent or higher (WHO and UNICEF 2012; UNICEF 2012).[5] Similarly, as shown in Figure 5.1, a suggestive correlation can be found in India between open defecation and stunting: States (each represented by a bubble of size proportional to the State's population) with high open defecation rates feature on average also a higher percentage of stunted children.

Figure 5.1 The correlation in India between open defecation (% of households practicing open defecation in a given State for both urban and rural) and stunting (below-2 SD)



Source: Author's own, based on data from NFHS-3 (2007).

This association has been found also comparing the height of children of the same socio-economic status in West Bengal and Bangladesh: in Bangladesh with much less open defecation, children of the same socio-economic status are taller than their peers in West Bengal (Ghosh *et al.* 2014).

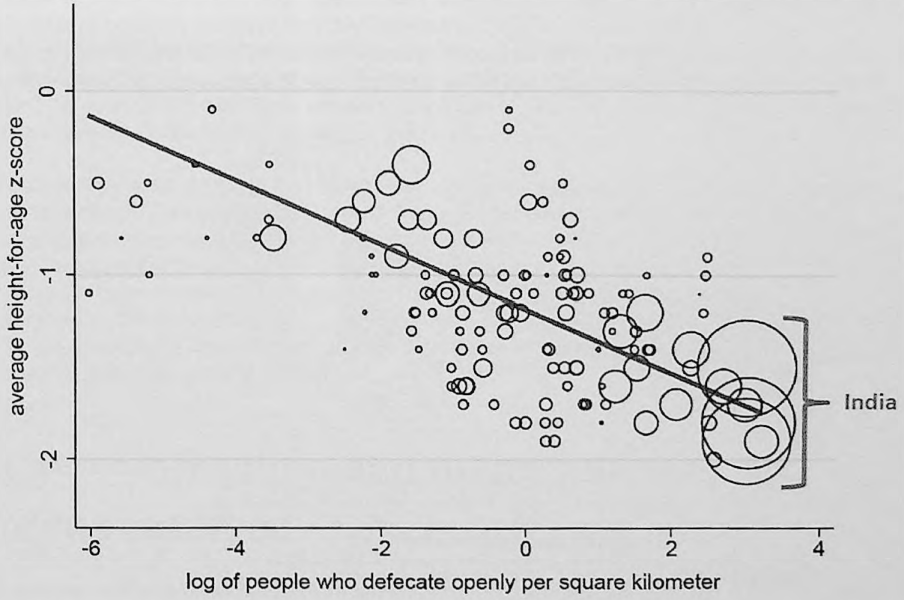
A breakthrough has been research by Spears (2014a). He has shown that open defecation is even more harmful where population density is high, presenting conditions in which children (and adults) are more likely to be exposed to infections from faeces. Comparing countries' DHS data he has found that while open defecation can account for 54 per cent of cross-country variation in child height, open defecation per square kilometre can linearly account for 65 per cent (Spears 2014b: 43,13). India's widespread open defecation and high

[5] Compiled by UNICEF New York based on the cited reference; see also 'A Promise Renewed' webportal www.apromiserenewed.org/.

population density thus constitute a double threat, and combine to place its large population at the extreme end of the international distribution, as shown in Figure 5.2. This is based on national averages. The implications need to be worked through for different environments. In densely populated high open-defecation Districts in India, like those of many Northern States (notably those surveyed by the Naandi Foundation because of their high undernutrition rates) we can ask whether well over half, and perhaps even two-thirds or more, of undernutrition can be accounted for by FTIs.

Figure 5.2 Stunting related to densities of population and defecation

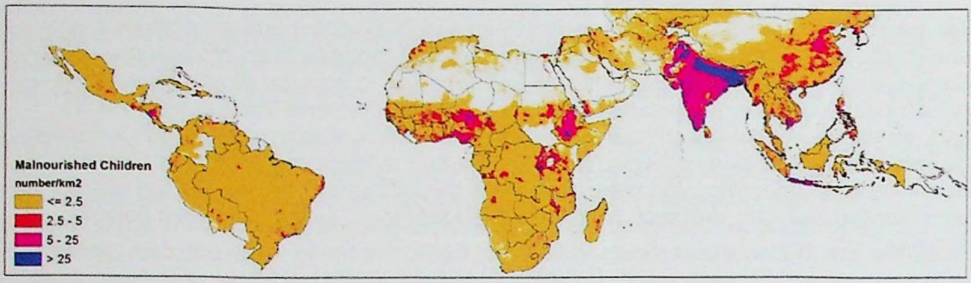
Each circle represents a single DHS round, reflecting one country in one year. The visible linear trend shows that children are shorter, on average, in countries where they are exposed to more open defecation with higher population density. The circle sizes are proportional to population.



Source: Spears (2014b: 40) copyright Spears, used with permission.
Note: It is difficult to conceive any more dramatic indication of the Indian crisis than the three large circles at the bottom right.

The world map of undernourished children per square kilometre (Figure 5.3) shows the extensive concentration in the Gangetic basin, the Hindi belt, which also has the most extensive concentration of open defecation anywhere in the world. To make things worse, overall in rural India and especially in the north, the amount of daily defecation per unit area increased in the inter-censal period 2001-2011 (Spears 2014a), as population growth was faster than the spread of sanitation. This trend has been especially concentrated in the North, perhaps representing a long-term trend in the Northern States towards greater exposure of children and adults to FTIs and to consequent loss of food and undernutrition, offsetting any improved access to food.

Figure 5.3 Density of malnourished children per square kilometre



Source: Ericksen *et al.* (2011, map 3.14, p24). Reproduced with kind permission of CGIAR (under CC BY-NC-ND).

6 Earlier evidence

With hindsight, it is remarkable that the blind spot should have persisted for so long. Before 2011 and the above mentioned research, there was already strong evidence of the links between WASH and undernutrition. It was known that sanitation and hygiene prevented and reduced stunting. Esrey (1996) had shown from a sample size of around 17,000 children collected from three continents that improvements in sanitation resulted in height increases ranging from 0.8cm to 1.9cm, larger than those found in many nutritional interventions. Outcomes of various meta-analyses had shown that the single practice of handwashing with soap could reduce the incidence of diarrhoea in children under five by 37-48 per cent (CHERG 2010; 3IE 2009; Ejemot *et al.* 2008; Fewtrell *et al.* 2005; Curtis and Cairncross 2003), and that sanitation reduced diarrhoea risk by 32-36 per cent (CHERG 2010; 3IE 2009; Fewtrell *et al.* 2005).

An authoritative WHO publication (Prüss-Üstün and Corvalàn 2006: 44), had concluded that 'overall, 50% (39% - 61%) of the health burden of malnutrition was [...] attributable to the environment, and in particular to poor water, sanitation and hygiene.' Another WHO publication had stated that 100 per cent of all the annual worldwide cases of ascaris, trichuris and hookworm infestation were attributable to inadequate sanitation and hygiene (Prüss-Üstün *et al.* 2004). WHO (2007), concluding that improved sanitation, along with other WASH components, was essential for sustainable reduction in intestinal nematode infections, to which may be added other FTIs. In sum, for improving nutritional status, effective WASH interventions had already earlier been found to be vital (see e.g. Bhutta *et al.* 2008).

7 The enigma of the persistent blind spot

The resolution of the Asian enigma poses another puzzle though: the enigma of the persistence of the blind spot. Given the evidence that already existed, how was it that the significance of FTIs as a cause of undernutrition was, and in some circles still is, unrecognised and its implications unexplored.

Three clusters of explanation can be suggested.

7.1 Institutional marginality and silos

For many years, nutrition itself was an unwanted and insignificant orphan in governments, and shuffled from department to department. To gain recognition of its importance, to raise its profile, to secure funding and staff and to bring it in from the wings, were battles to be fought and which generated commitment to the programmes that followed. For its part, sanitation was always and still largely remains a junior sibling to water, with a smaller budget. It too had its own battles to fight. The resulting nutrition and sanitation silos, as is usual, were inward looking and preoccupied with their own programmes. On top of this, both nutrition and rural sanitation have been difficult areas in which to achieve notable success.

7.2 Psychology: Oral over anal

At both personal and professional levels, there are strong preferences, which do not need elaboration, for the oral over the anal, for things which are clean to dirty, odourless to smelly, hard to soft and tidy to untidy (Chambers 1983: 173). Valerie Curtis (2013) has examined in detail the human emotion of disgust, and subtitled her book *The Science behind Revulsion.* Most adults would much rather feed a child and wipe its face than dispose of its faeces and wipe its bottom. The professional psychological dimension is both fascinating and revealing. There has been a pervasive shift in psychology from the preoccupation of Freud and the early psychoanalysts with the anal to the current striking focus, almost tunnel vision if the metaphor can be permitted, to the oral. According to Haslam in his delightful and insightful *Psychology in the Bathroom* (2012: 6-8) there are numerous journals dedicated to the study of eating and drinking and thousands of articles and many journals that explore the symptoms, causes and treatments of eating disorders such as anorexia nervosa and bulimia nervosa, but no psychological scientific journals devoted to the elimination of food and its disorders. The mouth remains visible and attractive, and the anus is kept out of sight, as in daily life.

7.3 Professional specialisation, incentives, tunnel vision and inertia

Nutritionists who have been professionally trained in nutrition then go on to work on nutrition. Similarly, the sanitation sector has been populated quite largely by those trained in engineering. College and university teachers who do the training have their notes and lectures and under pressure have little incentive to change them. Indeed, conservative academic colleagues might oppose including WASH in nutrition courses, or nutrition in those concerned with WASH. There are other reasons for specialisation. Epidemiologists and other professionals have to specialise and have incentives to narrow their vision and work in order to be able to publish in peer-reviewed journals – they study the studiable in order cost-effectively for a career to produce the publications essential for promotion. This has focused and limited attention largely to the diarrhoeas to the neglect of other FTIs and of their combined effects.

Let us explore this last point further.

8 Diarrhoea reductionism

When FTIs are being considered, by far the most attention has been given to the diarrhoeas. Nothing should detract from their seriousness. How diarrhoeal FTIs cause undernutrition is well known. Diarrhoeal episodes adversely affect the nutritional status of children: nutrients are evacuated; less is eaten during illness; and, as outlined above, absorption of nutrients is reduced (Ejemot *et al.* 2008) and energy diverted to producing antibodies to fight off

pathogens. Each diarrhoeal episode reduces resistance to infections and impairs growth and development when repeated and prolonged (Ejemot *et al.* 2008). Diarrhoeal diseases are the second leading cause of death in children under five years old, and kill around 760,000 children under five each year (WHO 2013b). In India alone, diarrhoeas caused the deaths of 212,000 children younger than five years in 2010, accounting directly for 12.6 per cent of child deaths, significantly more than the worldwide average of 9.9 per cent (Liu *et al.* 2012).

However, the relative significance of diarrhoeas needs to be qualified. Their dramatic clinical manifestations, their visibility, the ease with which they can be recorded and the fact that they can kill, have led to their receiving attention to the relative neglect of the other FTIs, many of which are to varying degrees subclinical and asymptomatic but continuously debilitating. Also, the rigour of much medical research demands measurement and statistics, to which diarrhoeas lend themselves, whereas subclinical FTIs are less visible, and harder, more time-consuming and more expensive to measure. Diarrhoea as morbidity reported through recall is straightforward to obtain though it has been shown to be systematically unreliable (for India, see Das *et al.* 2012). A further limitation is that using diarrhoea as an indicator for health outcomes of sanitation does not take account of the causality of other FTIs. But there are statistics for diarrhoeas and statistics are needed for rigour and acceptability.

In consequence, the focus on diarrhoeas to the neglect of other FTIs is pervasive and out of all balance. Endless examples could be given. To illustrate the point, in its section on health and nutrition, the Handbook of Development Economics (Schultz and Strauss 2008: 3565) lists diarrhoeas twice and intestinal helminths once, but none of the other FTIs. The 2008 *Lancet* Maternal and Child Undernutrition Series was modelled entirely through diarrhoea. Jean Humphrey in her seminal *Lancet* article on tropical (environmental) enteropathy (Humphrey 2009) constrained perhaps by data availability and perhaps by the conventional stringency of editorial policy and the need to make an impact, compared EE only with the diarrhoeas and not with other FTIs. Article after article has *diarrhoea* in its title to the point where it becomes incestuous: review articles are again and again tied to the diarrhoeas to the neglect of other FTIs, because there are comparable numerical data, for instance: 'Domestic hygiene and diarrhoeas – pinpointing the problem' (Curtis *et al.* 2000); 'Effectiveness and sustainability of water, sanitation, and hygiene interventions in combating diarrhoea' (Snilstveit and Waddington 2009); and the much cited Cochrane systematic review 'Interventions to improve water quality and supply, sanitation and hygiene practice, and their effects on the nutritional status of children (Review)' (Dangour *et al.* 2013). These assessed impact in terms of diarrhoeal morbidity, as inevitably did the review of the reviews 'The cost of a knowledge silo: a systematic re-review of water, sanitation and hygiene interventions' (Loevinsohn *et al.* 2014). Indeed, to underline the point, Loevinsohn *et al.* list no less than 13 earlier systematic reviews which are all of the diarrhoeal impacts of WASH, the first in 1983 (Blum and Feachem 1983). More does not need to be said. Because they are measurable and measured, a convenient and universal indicator, the diarrhoeas lend themselves not only repeatedly to research, but to institution building. The International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) is world-renowned. There is no International Centre for FTI Research.[6]

[6] It must be pointed out, however, that the ICDDR,B conducts much ground-breaking research beyond the diarrhoeas, and now including EE.

9 The scale and significance of other FTIs

Besides the diarrhoeas, infections with other continuously debilitating FTIs are widespread in many countries which have poor sanitation. WHO estimates, for instance, that in 2011 around 240 million children in India (of which 69 million were pre-school age and 171 million school age children) needed chemotherapy treatment for Soil-Transmitted Helminths.[7] Cairncross (1998) reported that ascaris could 'steal' as much as one third of the nutritional intake a child receives through feeding;[8] hookworms are a major cause of anaemia; and trichuris results in chronic colitis in infants and stunting in children, with their effect on children so dramatic and long-lasting that mothers tend to consider the related diarrhoea a 'normal' condition (Cairncross 1998). While de-worming strategies result in significant improvements of children's nutritional status (Hall *et al.* 2008), de-worming needs to be repeated at least yearly, since reinfection rates are high after treatment (Norhayati *et al.* 1997). There are also dangers of a build-up of resistance.

The most nutritionally significant FTI is probably environmental (earlier known as tropical) enteropathy (EE). Though recognised earlier as 'tropical sprue' (Lindenbaum 1973) and intermittently reviewed (e.g. Fagundes-Neto *et al.* 1994), it has only come into prominence following the 2009 article in *The Lancet* by Humphrey. (A recent comprehensive overview (Crane *et al.* 2014) uses the term *environmental enteric dysfunction* to describe 'an incompletely defined syndrome of mucosal and submucosal inflammation, reduced intestinal absorptive capacity and reduced barrier function' but EE is currently the more generally accepted term). EE is a subclinical condition linked mainly with the ingestion of faecal bacteria. These damage the wall of the small intestine: villi are atrophied and blunted and their area reduced so that they can absorb less nutrients. This damage also results in gut hyperpermeability, evoking energy and protein consuming immune response to fight the infections. Studies of Gambian infants living in dirty conditions have been found them to enter 'a near-continuous state of growth-suppressing immune response: dietary nutrients [are] repartitioned away [...] in favour of glucose oxidation and synthesis of acute-phase proteins and other immune mediators' (Humphrey 2009: 1034). EE is a continuous largely subclinical condition inhibiting growth. Lunn *et al.* (1991) found that an indicator of gut permeability (the lactulose to mannitol urinary excretion ratio which is associated with EE) explained 43 per cent of growth in height. Recent studies have confirmed the association of inflammation and gut permeability with stunting. Kosek *et al.* (2013), after controlling for diarrhoeal disease, have found a relationship between intestinal inflammation and lineal growth failure. Lin *et al.* (2013) have found faecal contamination associated with EE and growth faltering in rural Bangladesh, with a stunting prevalence 22 per cent lower among children living in clean households and height gains largest with joint improvements in terms of water, sanitation and hygiene conditions. They concluded that their results were consistent with the hypothesis that environmental contamination causes growth faltering mediated through EE. Findings from a study in Zimbabwe suggest that extensive enteropathy occurs during infancy and that stunting is characterised by chronic inflammation (Prendergast *et al.* 2014). Ngure *et al.* 2014 have reviewed and summarised pathways through which WASH may affect early child development primarily through inflammation, stunting and anemia. From their review 'Environmental Enteropathy: Critical Implications of a Poorly Understood Condition', Poonam and Petri (2013) conclude that '... the clinical impact of environmental enteropathy is just starting to be recognised. The failure of nutritional interventions and oral vaccines in the developing world may be attributed to environmental enteropathy, as the intestinal absorptive and immunological functions are significantly deranged.' Prendergast and Kelly (2012: 756) in their article 'Enteropathies in the Developing World: Neglected

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7 Retrieved 21 December 2012 from www.who.int/neglected_diseases/preventive_chemotherapy/sth/en/index.html.

8 The amount stolen varies. Ascaris infections tend to be heaviest in a few individuals (pers.comm. S. Cairncross 2012). The figure of one third is at the high end of the scale, not an average.

Effects on Global Health' state that EE is 'ubiquitous among people living in unhygienic conditions' and is likely to mediate stunting and anemia and to underlie poor oral vaccine efficacy and human immunodeficiency, while interacting effects of infection and enteropathy drive a vicious circle that can propagate severe acute malnutrition which underlies half of under five year old deaths.

EE may be the most significant FTI, but when all the FTIs are taken together, the diversity, extent and probable debilitating impact of non-diarrhoeal FTIs on nutritional status is even more striking. Yet it does not seem common practice to list or consider these FTIs together or their combined wider impacts. EE, along with worm infestation and other subclinical FTIs not only reduces nutrient absorption and aggravates undernutrition and stunting but also contributes to cognitive deficits; WHO (2005), for instance, estimated an average Intelligence Quotient (IQ) loss per worm infection of 3.75 points, amounting to a total IQ loss of 633 million points for the world's low-income countries. Combinations of EE with worms, giardia and other continuous infections can be expected to have interactive as well as cumulative effects on a child, damping down and reducing activity, play and learning, as well as affecting more measurable indicators of growth. And these are in addition to, as well as interacting with, the diarrhoeas.

The accumulation of evidence suggests that the total combined impact of non-diarrhoeal FTIs on stunting is far more than that of the diarrhoeas. The non-diarrhoeal FTIs are likely to have greater adverse effects on children's nutritional status, and so on morbidity and mortality, than was earlier generally recognised. Jean Humphrey has described the diarrhoeas as only the visible tip of a much larger subclinical iceberg (pers. comm., November 2011). From the literature reviewed, child mortality rates and height for age (stunting) seem thus preferable to the incidence of diarrhoeas as composite outcome indicators.

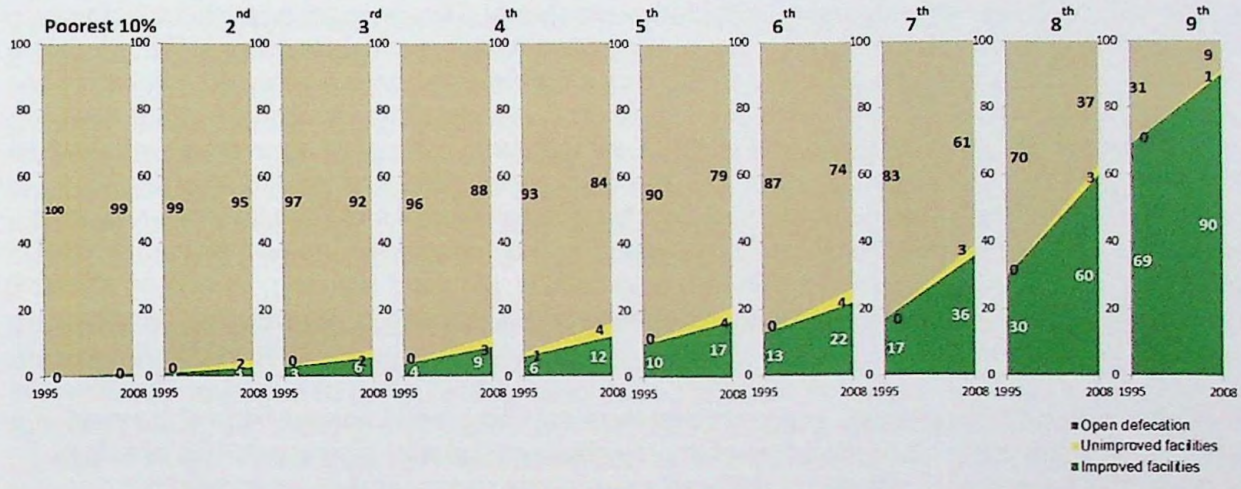
10 Open defecation, poverty and undernutrition: a syndrome

The unacceptable effects of undernutrition – including suffering and diminished quality of life, inhibited physical growth, impaired immune response, impeded cognitive development, lower school attendance and performance, constrained livelihoods and earning power, and losses to the wider economy – are so many and so multiple that they are easy to underestimate (see section 'Economic losses from FTIs' p22 below). Such avoidable human suffering is intolerable.

To illustrate the syndrome of open defecation, undernutrition and poverty, we focus on India because of its scale, and in order to give a concrete example. Although 291 million people in India gained access to improved sanitation from 1990 to 2012, over 597 million still defecated in the open in 2012, according to the 2014 JMP update (WHO and UNICEF 2014). According to the 2001 and 2011 censuses (GOI 2012, 2002), the total number of open defecators in India went down by 50.9 million in the intercensal period, but the improvement in urban areas combined with the increased number of households masked the fact that the number of rural households without latrines actually *increased* by 8.3 million (Hueso and Bell 2013: 1003) and average exposure to open defecation and so to FTIs increased (Spears 2014a). India's proportion of open defecation in the world has continued to rise: 51 per cent of all the world's open defecators were in India in 1990, 55 per cent in 2000 and around 60 per cent in 2012 (WHO and UNICEF 2014). The distribution of open defecation by wealth decile is sharply skewed in India, as shown for rural areas in Figure 10.1 below with

pronounced contrasts also between districts (Spears et al 2013). The wealthiest 40 per cent of Indians are 10 times more likely than the poorest 40 per cent to use improved sanitation (Narayanan *et al.* 2011).

Figure 10.1 Rural trends in sanitation by wealth decile in India

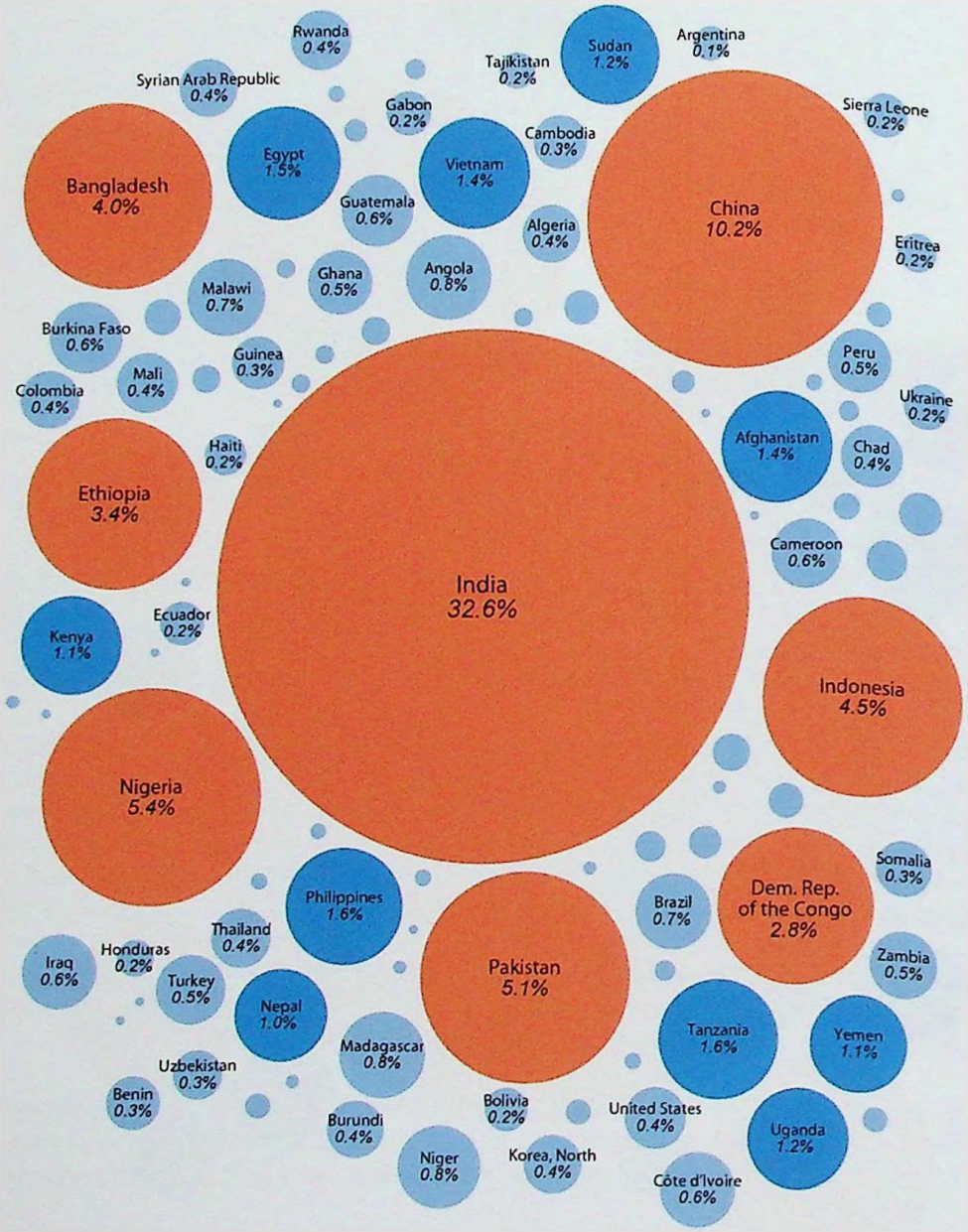


Sources: NFHS (1995, 2000 and 2007), prepared by UNICEF Statistics and Monitoring Section, May 2010. Reproduced by kind permission of UNICEF.

Despite the intended focus given by the national Total Sanitation Campaign during the period covered in Figure 10.1 to Below Poverty Line households, progress was negligible for the poorest in rural areas, while most gains were made by the better off. Urban OD is also overwhelmingly a phenomenon of the poorest.

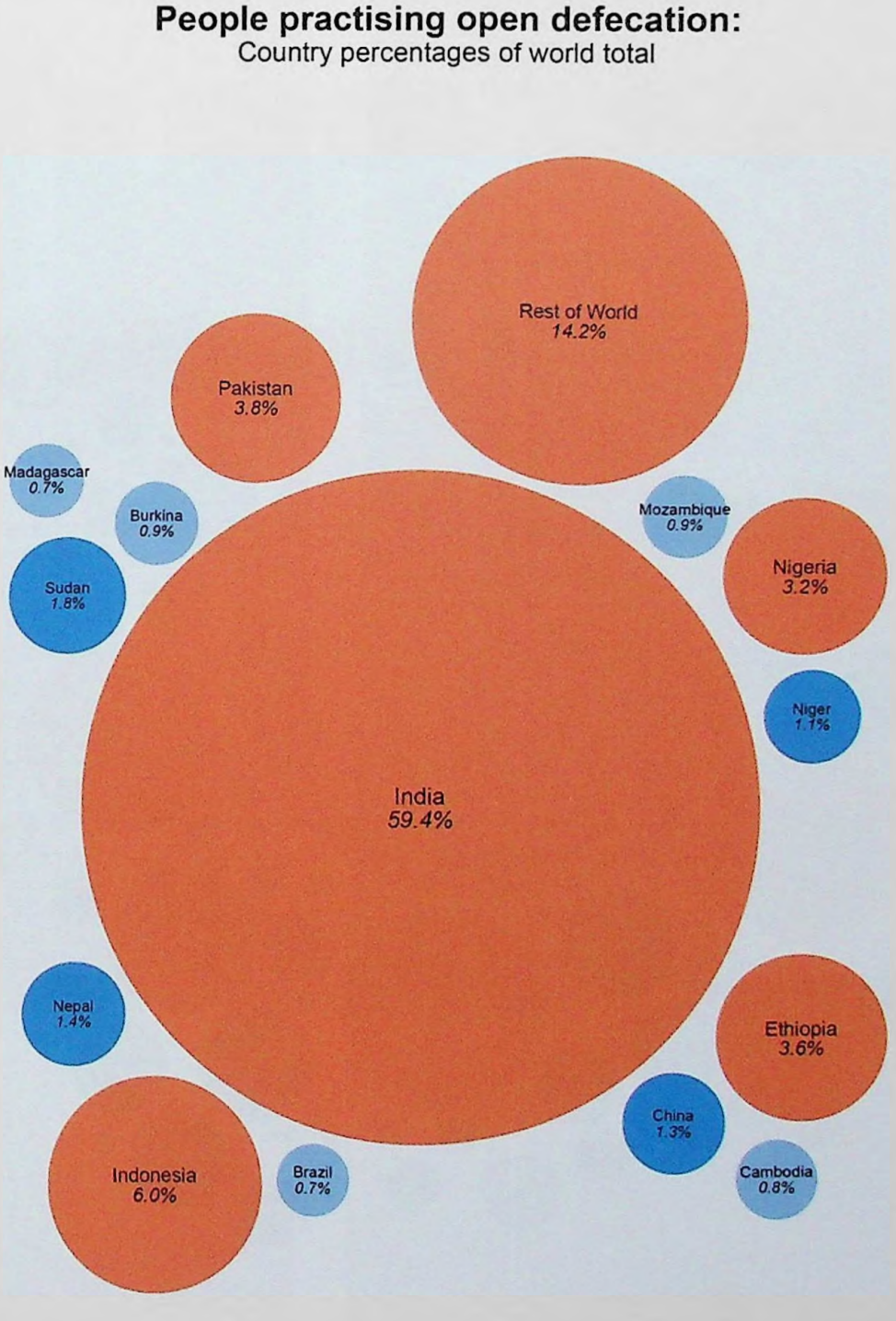
The scale of undernutrition and open defecation relative to other countries is indicated in Figures 10.2 and 10.3, and their links with poverty in Figure 10.4.

Figure 10.2 Children stunted in India and other countries



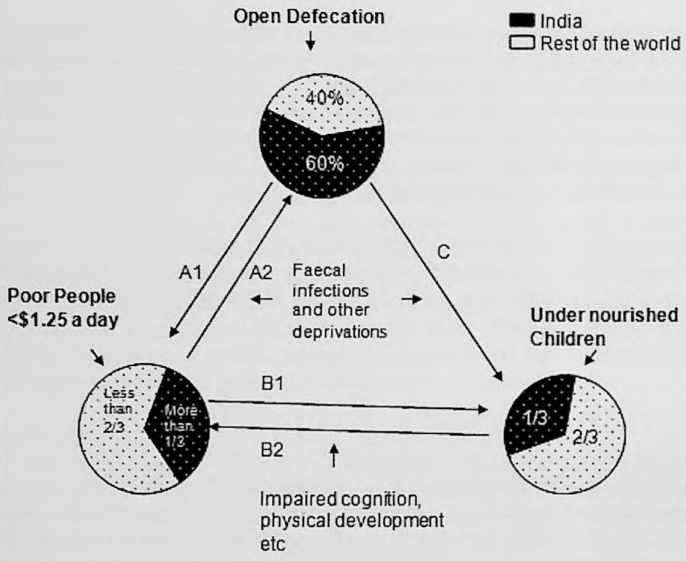
Source: Authors' own based on: The Guardian (UK) newspaper, Tuesday 14 September 2010, posted by Jonathan Glennie www.guardian.co.uk/global-development/datablog/2010/sep/14/bottom-billion-poverty

Figure 10.3 People practising open defecation in India and other countries



Source: Authors' own based on WHO and UNICEF (2012).

Figure 10.4 Links between open defecation, poverty and undernutrition



Source: Author's own.

India accounts for approximately one third of the stunted children in the world, 60 per cent of the open defecation in the world, and over one third of those living on less than US$1.25 a day. Figure 10.4 depicts some of the links existing between OD, poverty and undernutrition, which combine in to reinforce each other, some of which are as follows:

A1: OD and lack of sanitation and hygiene cause and sustain poverty in many ways. The most obvious are through FTIs, their physically disabling effects reducing capacity to work and impoverishing through medical expenses (Krishna 2010). Other links include the many deprivations imposed on women having to defecate in darkness, constipation and other suffering from having to postpone urination and defecation, risks of assault, rape and abuse (EPW 2012), indignity, loss of time and sleep, and lack of privacy for menstrual hygiene.

A2: Poverty sustains open defecation and unhygienic behaviour in many ways. Only a small minority of rural people in the bottom income groups have access to sanitation (see Figure 10.1).

B1: How poverty leads directly to undernutrition is well recognised, including lack of food, whether grown or purchased, poor diets, lack of micronutrients, lack of energy for work, unhealthy environments, and lack of safe drinking water.

B2: The link from undernutrition to poverty is also strong. Childhood undernutrition reduces adult economic productivity (Black *et al.* 2008). Undernutrition and anaemia in pregnant mothers lead to low birthweight children (Balarajan *et al.* 2013), whose subsequent undernutrition not only results in underweight, wasting and stunting but also slows and limits cognitive development (Spears and Lamba 2013; WSP 2013). Repeated episodes of diarrhoea during early childhood have proven adverse impacts on cognitive development, and diarrhoea has been shown to be the best single predictor test of nonverbal intelligence scores and even school performance at 6–12 years of age (Dillingham and Guerrant 2004). Stunted children earn less in adulthood, and have been found vulnerable to having impaired

immune systems, heart disease and being obese (Vogl 2014; Currie and Vogl 2013; Case and Paxson 2008).

C: The link between OD and undernutrition and stunting is the major theme of this paper. FTIs can be understood to interact and combine also with undernutrition in a negative syndrome. FTIs adversely impact nutritional status. Undernutrition in its turn brings susceptibility to respiratory diseases and other infections (WHO 2007). Infectious diseases are the main killers of children under the age of five years in conditions like rural India. While not the *primary* cause of these deaths, undernutrition has been considered the *underlying* cause of about half of them (Schlaudecker *et al.* 2011).

Though these links are almost self-evident, their combined impacts as a syndrome may be easy to underestimate. Taken together each arrow has more force through the circularities of the syndrome than it would have on its own. FTIs stunt, not only directly but also through circular and indirect pathways.

11 Economic losses from FTIs

The relative neglect of non-diarrhoeal FTIs affects assessments of the economic impact of sanitation and hygiene. In its flagship report *Economic Impacts of Inadequate Sanitation in India* (WSP 2011) the Water and Sanitation Program of the World Bank (WSP) estimated that the total annual economic impact of inadequate sanitation in India in 2006 amounted to US$48 per person or about 6.4 per cent of the country's GDP. As a proportion of GDP only Cambodia was higher, at 7.2 per cent (Hutton et al 2008) while most African countries were in the much lower range of 1 per cent to 2 per cent (WSP 2012a, b; WSP 2011). Economic impact was calculated on the basis of impacts related to health, domestic water, access time, and tourism. The impact on poorer people was found to be disproportionate. The health costs took account of diarrhoeas and intestinal helminths.

However, six less visible and less measurable effects of lack of sanitation and hygiene were not taken into account. First, FTIs and related diseases, many of which may often be sub-clinical, like giardiasis, most liverfluke, some hepatitis, tapeworms, some other zoonoses, and above all EE, when added together and combined interactively can be expected to have much greater impact on undernutrition than the diarrhoeas. Menzies *et al.* (1999), for instance, found an association between lower GDP per capita and more severe EE. Second, the report states (WSP 2011: 83) that account was not taken of low birth weights, and the consequent poor prognoses for children. These low birth rates may often result from FTIs and the physical and social deprivation suffered by women from lack of sanitary facilities. Third, adult immune systems are weakened by child undernutrition and adults who were undernourished as children run the risk of having higher prevalence of diabetes, obesity (Yang and Huffman 2013) and other non-infectious conditions (Adair *et al.* 2013). Fourth, lack of sanitation has costs in stress and inconvenience, and discriminates against women and their employment. Fifth, impaired cognitive development is associated with stunting (Spears and Lamba 2013; Dillingham and Guerrant 2004). Finally, school attendance, retention and performance, especially of adolescent girls starting menstruation (Pearson and McPhedran 2008) are affected. According to Dillingham and Guerrant (2004), the best surrogate predictor of cognitive development and school performance is height-for-age Z score at two years old, the anthropometric measure that also best correlates with burdens of diarrhoea at 0–2 years old. Taken together, these factors which were not accounted for in the WSP (2011) calculation of GDP loss in India, may well offset any inflation from the high diarrhoea figure used, and even mean that the 6.4 per cent estimate GDP loss due to inadequate sanitation in India was an underestimate.

12 The case for inclusive concepts

The accumulation of evidence adduced so far in this paper builds and supports the core and central conclusion that poor sanitation, lack of hygiene, and open defecation, by spreading FTIs, can be major causes of undernutrition, and that this link has been largely overlooked, neglected and a blind spot.

Concepts of undernutrition have tended to be formed and framed by professional specialisations and humanitarian concerns. We see and work on what we are trained to see and work on: epidemiologists have incentives, at least early in their careers, to narrow their attention to single infections or conditions and agriculturalists to food production, while nutritionists, economists, public administrators, political scientists and committed activists concentrate on the immediate and common sense humanitarian imperative of enabling children and others to have an intake of more and better food. We have already noted the bias towards studying diarrhoeas and over attributing causality to them associated with their measurability. Concepts are needed which are holistic and inclusive.

They also need to be open to local variation. At a high level of generality, the puzzle with which we started, the 'Asian enigma' of taller Africans than Asians despite lower average incomes, has been largely resolved. The persistence of undernutrition and stunting in India is no longer an enigma. It is largely explained by the international comparisons of open defecation in DHS surveys together with population density. The persistence of undernutrition which has been puzzling in other countries like Indonesia may also be largely or entirely explained similarly. There will be variations according to local conditions. But the conclusion follows that fully open defecation free conditions and hygienic practices should in many contexts reduce undernutrition by half or more.

Caution is needed, though, with the generality of any such conclusion. The economic analyses discussed above show such striking contrasts that we can ask whether they present another, though related, puzzle. Why is it that the percentage of GDP lost through lack of sanitation in some countries – Cambodia 7.2 per cent, India 6.4 per cent – is so much higher than in say Niger 2.4, Indonesia 2.3, Vietnam 1.3, Madagascar and Tanzania 1, and Kenya 0.9? Why are most African countries in the range of only 1 to 2 per cent? We cannot pretend to a full answer. Physical factors like temperature and humidity may be significant variables. Open defecation and population density may explain much but living in nucleated villages as in much of West Africa, or on scattered smallholdings as in much of East Africa might show up as the same rural population density but with different exposure to FTIs. Other factors are likely also to be significant: for instance, open defecation on the part of male nomadic pastoralists in hot dry climates where faeces dry up quickly and blow away may have insignificant health effects, or considerable effects where pastoralist women, children and old people live in and defecate close to nucleated settlements.

The balance of causalities of undernutrition will also vary, with implications for choice of interventions. In Niger, for instance, which has the highest stunting rate among 36 countries reviewed (Vollmer *et al.* 2014), absolute food shortages associated with droughts, locusts and bad seasons (Sanchez-Montero *et al.* 2011) are likely to be more significant than, say, in Southern Ghana with more reliable rainfall. Micronutrient deficiencies of zinc, vitamin A, iodine and iron vary locally in importance. The priority of actions on breast feeding, balanced diets, and much else that is the stock-in-trade of nutrition programmes will vary. And now WASH and FTIs further complicate the scene.

The need to take account of the local, and to assess a balance of causalities reinforces the case for concepts that are inclusive: balance is only possible when the full range of causality and prevalence, and by implication interventions to tackle causes, is initially on the table.

13 Reframing undernutrition inclusively: the FTIs and the 5 As

To capture this full range we propose two concepts: FTIs, which we have already been using; and the 5 As of undernutrition which we now introduce. The FTIs broaden out from the reductionism of 'faecal-oral' which excludes for instance hookworm, schistosomiasis and trachoma which enter externally; and the 5 As of undernutrition broaden out to include the FTIs. The 5 As relate to pathways and processes: the first two As concern food into the mouth; the last three concern the FTIs and what happens inside the body and what comes out of the anus. As we shall see, these two concepts – FTIs and the 5 As[9] – taken together generate an agenda for research, professionalism, policy and practice.

13.1 The first two As: food into the mouth

The first two As concern getting food into the body.

13.1.1 Availability

This agricultural production and food stocks approach is common sense. There has to be enough food in the country and distributed throughout it. India has succeeded in avoiding major famines since 1943 (Devereux 2007), ensuring overall food availability. The focus of this typically Food and Agriculture Organization (FAO) approach has been extended conceptually and practically to embrace food systems for better nutrition (FAO 2013). Food systems include availability of adequate quantity and quality (balanced diet, micronutrients, lack of contamination and pollution etc) of food at all times of the year.

13.1.2 Access

This great contribution of Amartya Sen (1981) is now well understood. People can die of famine when there is food available if they do not have 'entitlements', and cannot obtain it. Though full-blown famines in India and most of the world have been eliminated, for the most vulnerable and disadvantaged groups, access to adequate food remains an acute problem often with a seasonal dimension. Access is thus a major concern of policy and practice. The standard diagnosis of undernutrition is that children are not getting enough food and not enough good food, and that they suffer from micronutrient deficiencies. National programmes seek to improve and increase food and its delivery, especially to the most vulnerable and deprived. This is then the overwhelming focus of research, advocacy and action. A collection of papers on nutrition in India (Haddad and Zeitlyn 2009) called for improved governance, new initiatives, promoting the status of women, more resources, better monitoring of the Integrated Child Development Services (ICDS) and more and better data on nutritional status in the Indian context. Ration cards, the Public Distribution System, midday meal schemes in schools and pre-school feeding in Anganwadi centres, the ICDS, food subsidies, and other related issues of governance and food justice, are and will rightly remain the subject of much analysis, recommendations and action (see for instance Saxena 2012a and b; Haddad *et al.*

[9] The first three As – availability, access and absorption – stressing absorption were the theme of M.S. Swaminathan's keynote address in 2008 to the Third South Asian Sanitation Conference in Delhi. The fourth A – antibodies – was added, drawing on Humphrey (2009) in a brainstorming with Kamal Kar.

2012; Mander 2013). Nothing that follows should detract from the value of such approaches, nor from their achievements.

That said, there is widespread evidence of the limitations of feeding programmes in reducing undernutrition and stunting (see for instance Dewey and Adu-Afarwuah 2008). We suggest that the humane and common sense imperative of getting enough good food into the mouths of children tends to obscure the nutritional significance of what happens to the food after it has been eaten. This brings us to:

13.2 The last 3 As: infections from the anus

While the first two As concern getting food into the body, the next 3 As concern the infections which then come out, the FTIs and their effects:

13.2.1 Absorption

Much food that is ingested is not absorbed. This can be understood to happen in three ways which also interact with each other:

i. *Damage to the wall of the gut.* In particular, bacterial infections and parasites damage the villi (the folds which multiply the absorptive area) of the small intestine and reduce surface area and absorptive capacity (Humphrey 2009).
ii. *Diarrhoeas* including but not only cholera, shigellosis, rotavirus, cryptosporidiosis, and campylobacter, dehydrate and evacuate nutrients which then cannot be absorbed (Black *et al.* 2008).
iii. *Intestinal parasites* steal nutrients from the child, or more generally the human host, as well as damaging the wall to which they adhere. Parasites implicated include giardia, amoebiasis, ascaris, hookworm (which feeds on blood and causes anaemia) trichuris and tapeworms. For instance, a review published by Simavi (2012) estimates that 44 million women in India are infected by helminths at any one time, causing increased anaemia rates, low infant birth weight, and increased intrauterine growth retardation.

13.2.2 Antibodies

As with EE, infections in the intestine which penetrate into the rest of the body are fought with antibodies. Producing these antibodies diverts nutritional energy and proteins from growth to defence. Comparing studies of chicks reared in clean conditions, in dirty conditions with anti-biotics (known as 'growth permitters' in the context) and in dirty conditions (Roura *et al.* 1992), with a study of Gambian infants (Campbell *et al.* 2003) Humphrey wrote that 'when confronted by incessant microbial challenge, both the Gambian infants and chicks studied entered a near-continuous state of growth-suppressing immune response: dietary nutrients were repartitioned away from anabolism in favour of glucose oxidation and synthesis of acute-phase proteins and other immune mediators' (Humphrey 2009: 1034). The same could be expected with other FTIs which provoke immune response. How much nutritional energy is consumed in this immune response has not been estimated in any of the literature we have reviewed. In their overview, Crane *et al.* (2014) find that despite the importance of chronic inflammation and of bacteria crossing the gut wall and activating the immune system, this remains poorly understood, partly because it is so difficult to study.

13.2.3 Allopathogens (Greek allos=other)

We have identified Allopathogens as a category designed to draw attention to the multiplicity of FTIs including those that are relatively neglected and are easy to overlook. Besides those pathogens that more directly affect absorption, there are a striking number of others. These include Hepatitis A, B and E, typhoid fever (bacteria, salmonella), liverfluke, poliomyelitis and

other enteroviruses, neurocysticercosis (causing some one third of cases of epilepsy worldwide), schistosomiasis (200 million people affected), trachoma (80 million affected), and other zoonoses transmitted through intermediate hosts. These have varied multiple effects on absorption, antibodies, and physical disabilities.

14 The future: practical actions

Efforts to integrate WASH in nutrition have been increasing (see the *Resource Guide on Water, Sanitation, and Hygiene in Nutrition Efforts* (WASH Advocates, October 2014). Supporting going beyond these efforts, the inclusive framework of the FTIs and 5 As points to new emphases and foci for medical and nutritional research and for professional training and orientation and policy and practice.

14.1 Medical and nutritional research

Much research takes a long time between conception and funding, and its later consummation. Rigorous Randomised Control Trials are costly in money and human resources and laborious, postpone learning for years and once embarked on are difficult to alter or abandon: moreover, reduced stunting takes time to show up. The results of the Zimbabwe Research on cleanliness, embarked on in 2012 will not be known until 2016, until which time some cautious professionals may continue to describe EE as a hypothesis.

The danger is that both nutrition-related and WASH-related research will be denied flexibility and fenced in by long-term funding and early commitments, and so each may be unable to include the other. The question we ask is whether much research designed to be conventionally rigorous through large sample sizes, and treatment and controls, is like a supertanker: if on nutrition unable to change course and include WASH, or if on WASH unable to change course and include nutrition; or whether research has the flexibility to recognise and devote resources to new priorities if these come to make sense. A superordinate question is whether the relative allocation of research funding and resources needs balancing to give more weight to WASH and the FTIs.

Among the FTIs another issue of balance is the need to offset the diarrhoea bias and reorient priorities to provide more research funding to support the neglected investigation of non-diarrhoeal FTIs and FTI interrelationships. With the narrowing of focus that is necessary with specialisation, some of this can be expected to entail more work on, for instance, individual soil-transmitted helminths such as hookworm, ascaris and trichuris, and on the FTIs of the fifth A – allopathogens. To a limited degree this has been happening with the new prominence of Neglected Tropical Diseases (NTDs). Other candidate priorities concern more directly the links between open defecation, FTIs and stunting. What research priorities should be will depend on trade-offs between cost, professional time, timescale before results are available, relative ease of research and potential benefits. We do not presume to be able to assess these or to make definitive judgements, nor to produce an authoritative list.

The 5 As reframing, together with the evidence adduced above, generates its own research agenda:

- ***The prevalence of EE.*** This is a major unknown. In an earlier paper (Chambers and von Medeazza forthcoming 2014) we asked: among children where open defecation is widespread, is EE found in 20 per cent, 50 per cent, 80 per cent, or more? In relation to studies in hand in Bangladesh, Kenya and

Zimbabwe to assess the share of stunting attributable to sanitation and related factors, an authority in the field has been quoted as asking similarly 'Is it 50 per cent? Ninety per cent? That's a question worth answering' (Stephen Luby, quoted in Harris 2014).

- ***Cheap, scalable methods for assessing the prevalence of EE***. EE is expensive and laborious to assess (Crane *et al.* 2014: 5). The important study *Environmental Enteropathy and Impaired Growth in Rural Bangladesh* (Lin *et al.* 2013), which found that poor household environmental conditions were associated with enteropathy and impaired growth, was constrained to limiting itself to 136 children. The contrast with the relatively easily and cheaply measurable diarrhoeas is stark. Research to identify new, non-invasive, cheap and quick biomarkers for EE which can be used at scale has to be a very high priority for funding.
- ***The relative significance of EE***. How significant is EE in terms of impact on undernutrition and stunting, and on cognitive development?
- ***The prevalence of other non-diarrhoeal FTIs, not just EE***. How prevalent are other non-diarrhoeal FTIs among children and others, and what are the percentages of these FTIs among those who are undernourished?
- ***Antibodies***. How much nutritional energy is used, and how much protein consumed, to make antibodies and to fight infections from FTIs? How relatively significant is this? We list this as a provocation, hoping that it will lead to medical researchers and experts pointing to sources, work already done, what is known, and what is not known. Is there or could there be any estimate of what proportion of nutritional energy loss results from immune responses and antibodies?
- ***Multiple infections and Severe Acute Malnutrition***. What are the cumulative and interactive effects of multiple FTIs in the same undernourished child or children? How significant are FTIs, as opposed to lack of food and micronutrients?
- ***Impacts of environmental cleanliness.*** What are the positive impacts on reduced stunting and child wellbeing of open defecation free conditions, good sanitation, hygienic behaviour and environmental cleanliness? Lin *et al.* 2013 have made a start towards answering this. The Zimbabwe research should eventually in 2016 provide some answers which will be accepted as having the authority of conventional rigour at scale.
- ***FTIs and annual food losses***. At both national levels, and globally, how many calories and how many millions of tonnes of foodgrain equivalents are wasted annually through FTIs?

This list has been generated by the analysis in this paper. For other recently identified research priorities, based on a critical review of Adair *et al.* (2013), see Bhutta (2013), and also Crane *et al.* (2014).

14.2 Professional orientation, training and incentives

A starting point here is a critically reflective examination of current professional orientations, at both personal and institutional levels. Nutritional, WASH, medical, administrative and other professional teaching and training can be challenged to move out of traditional comfort zones by:

- Reviewing and radical restructuring of curricula and syllabuses.
- Rewriting textbooks and broadening these to eschew narrow disciplinary or departmental tunnel vision.

- Confronting specialisation and incentive systems of journals and peer-reviewed publications where these stand in the way and discourage cross-disciplinary or unconventional research on neglected linkages.
- Offsetting the incentives of conventionally rigorous research which encourage concentration on what is readily measurable and easily controlled, and recognising and rewarding those who push the frontiers of knowledge by gaining insights in other ways.
- Setting up prestigious awards for work in this area.

The aim should be to create a new generation of medical, nutritional, WASH, administrative and other professionals with a broader awareness of the significance of FTIs in undernutrition and commitment to removing them through the elimination of OD, the use of improved sanitation, environmental cleanliness, access to safe drinking water and the adoption of key hygienic behaviours like handwashing with soap or ash.

15 In conclusion

A case can be made for assessing the relative significance, and costs and benefits, of interventions to tackle different causes. As a step towards this, it can be asked how OD, population density, FTIs and undernutrition map together. Can geographical hot spots be identified for priority interventions? How feasible is national, regional and local differentiation of funding and programmes to fit the relative significance of disparate causes and interventions?

The tragedy has been that while widespread OD has continued to stunt children and afflict adults on a vast scale, sanitation and hygiene have been accorded such a low priority. That has been changing and continues to change: sanitation and hygiene have moved and continue to move fast up the agenda. In all this, as we have seen, India stands out. OD and undernutrition in India present one of humankind's greatest and gravest problems. For that reason the potential for enhanced human wellbeing in India through sanitation, safe drinking water and hygienic behaviours is phenomenal. The national campaign of the Nirmal Bharat Abhiyan (Clean India Mission) launched in October 2014 by Prime Minister Modi, has a vision. In India and in all countries where OD is widespread, a future can be pictured with health, dignity and safety especially for women, sharp reductions in undernutrition and stunting across whole populations, children more active and achieving more of their potential, food access programmes with more food absorbed and less wasted through FTIs, poverty reduced, cognition improved, and higher GDP.

The concepts of FTIs and the 5 As reframe more inclusively how undernutrition is perceived, described and analysed. Our hope is that this reframing will contribute however modestly to a cleaner, healthier and happier world in which all children and adults are well-nourished and can grow and live to their full potential.

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