



Symptoms and medical conditions in 204 912 patients visiting primary health-care practitioners in India: a 1-day point prevalence study (the POSEIDON study)

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Summary

Background India has one of the highest disease burdens in the world. A better understanding of what ails India will help policy makers plan appropriate health-care services and infrastructure development, design medical education curricula, and identify health research priorities that are relevant to the needs of the country. The POSEIDON study aimed to record the prevalence of symptoms and medical conditions for which patients visit a primary health-care practitioner in India.

Methods We randomly selected 12 000 general practitioners, general physicians, and paediatricians from 880 cities and towns and invited them to record demographic details, symptoms, and medical conditions for every patient they saw on Feb 1, 2011. A further 1225 practitioners volunteered to participate and their responses were included. We did simple descriptive analyses of prevalence rates and used χ^2 tests to study comorbid associations. Through application of systems biology methods, we visualised inter-relations between organ involvement of diseases and symptoms and deciphered how these associations change with age and gender.

Findings We included responses from 7400 health-care practitioners, which represented data for 204 912 patients, who presented with 554 146 reasons for visit. Fever (35·5%) was the most common presenting symptom. More than half of all patients presented with respiratory symptoms across all age groups and regions of India. Other common presentations were digestive system symptoms (25%), circulatory symptoms (12·5%), skin complaints (9%), and endocrine disorders (6·6%). Hypertension (14·52%), obstructive airways diseases (14·51%), and upper respiratory tract infections (12·9%) were the most common diagnoses reported. Of note was that 21·4% of all patients with hypertension reported by the primary health-care practitioners were younger than 40 years. Anaemia was the fourth most common disease reported by these health-care practitioners and was most common in women of menstrual age living outside metro cities.

Interpretation The POSEIDON study provides insight into the reasons that patients visit primary health-care practitioners in India; our results highlight important social and medical challenges in the developing world.

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Introduction

Of the world's 7·5 billion population in 2015, 1·2 billion people live in India. Around 18% of all global deaths and 20% of loss of global disability-adjusted life years (DALYs) occur in India,¹ making it a country with one of the highest disease burdens in the world. Non-communicable diseases have recently overtaken communicable diseases as the leading causes of mortality and morbidity in India.² A vast and populous country such as India that has a significant health burden faces many challenges in the provision of health services. India needs to build appropriate health-care infrastructure, allocate appropriate health-care resources, and train medical and paramedical personnel in diseases that are most commonly encountered in clinical practice. Further, the country needs to develop preventive and public health programmes for diseases that have high morbidity and mortality, and prioritise research funds for diseases with an important health burden. These objectives

can only be met by interventions based on reliable, nationwide data on what ails India.

Health care in India is provided by 1·5 million practitioners registered with the Medical Council of India. Of these, 0·7 million are trained in modern medicine and 0·8 million are trained in alternative forms of medicine. Primary health-care providers in India include general practitioners (trained in modern as well as alternative forms of medicine), general physicians (internists trained in modern medicine), and paediatricians (trained in modern medicine). About 80% of patients visit a private practitioner, which they do at their own expense.

However, most health-related data in India are obtained from public hospitals and public health-care service units and because public facilities provide only 20% of all outpatient care in India, they, therefore, do not necessarily provide a true picture of the whole morbidity profile in India. The National Family Health

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Research in Context:**Evidence before this study**

We searched PubMed and the Google Scholar database to identify studies of health morbidity profiles in patients visiting health-care practitioners in India as well as globally. We used the search terms “patient morbidity profiles”, “health statistics”, “health surveys”, “health morbidity”, “general practice morbidity” and searched in English and French for work published between 1980 and 2011. Although the focus was on Indian studies, we included studies from all countries and analysed them for content and quality. The National Family Health Surveys (NFHS) are the only nationwide health surveys in India, but the health information captured in these surveys is very different from that in the POSEIDON Study.

Added value of this study

This nationwide study has evaluated health morbidity profiles of patients from all age groups, as reported by primary health-care practitioners from 880 cities and towns in India.

The results of the POSEIDON study are likely to be more reliable than self-reported symptoms and diagnosis from house-to-house surveys and also indicate the health-care needs of patients. Results obtained from this study complement other health-related observations made by previous research and also studies in progress in India.

Implications for all the available evidence

The insight gained into the main reasons for visits to a primary health-care provider in India, from the POSEIDON study, highlights the varied health-care needs across India for different regions and age groups from the health-care practitioner perspective. These findings are especially useful for forming appropriate health-care-related curricula. That the NFHS data has a very different structure to that of the POSEIDON study precludes meta-analysis; both datasets show a high level of heterogeneity within India and together can provide direction for implementation research in this area of public health.

Survey (NFHS) is the largest nationwide health-related survey in India that has been conducted in three rounds so far (1992–93, 1998–99, and 2005–06). However, these data are collected via self-reports and the focus has been on information related to fertility, infant and child mortality, contraception and family planning, maternal and child health, reproductive health, nutrition, and anaemia. Little information about disease patterns has been collected. Moreover, self-reports could result in under-reporting of disease patterns.

Collection of comprehensive health data is hampered by difficulties in accessing registries of health-care practitioners in India and because primary health-care providers do not keep electronic records for the patients they see. Thus, between 2003 and 2011 we, assisted by field workers from Cipla Ltd, have built our own registry of 110 000 actively practising private and public primary health-care practitioners spread across all states and union territories in India.

Practice-based surveys have provided useful and practical information for health policy planners in countries such as the UK,³ Singapore,⁴ Sri Lanka,⁵ Malaysia,⁶ and South Africa.⁷ Publicly available data from large and updated surveys, such as the National Hospital Ambulatory Medical Care Survey in the USA have been shown to stimulate public health research.

The Prevalence Of Symptoms on a single Indian healthcare Day On a Nationwide scale (POSEIDON) study was designed to investigate the point prevalence of symptoms and medical conditions for which a patient visits a primary health-care practitioner in India. In addition, POSEIDON also aimed to study the distribution of disease patterns across different regions in India, age-related and gender-related disease profile patterns, and comorbid conditions associated with common diseases.

Methods**Participants and study design**

We used SPSS version 11.5 (IBM, New York, USA) to invite randomly selected practitioners from our register of primary health care providers to participate in the study. We included general practitioners, general physicians, and paediatricians from cities and towns across all states and union territories in India in the study population. To adequately represent all Indian states and union territories, we used a sampling ratio of one doctor per 120 000 population, based on the population of the smallest union territory (Lakshadweep, where the population is 120 000 people). Then, applying this ratio elsewhere, we calculated the total number of doctors needed for inclusion in each state and union territory and arrived at a sample size of 12 000 practitioners.

To create a representative sample, we made suballocations for practice type, and aimed to select 70% general practitioners, 15% general physicians, and 15% paediatricians. Likewise, we selected 70% of participants from private clinics, 20% from private hospitals, and 10% from government hospitals to create a representative sample. For small union territories that required a sample size of four doctors or fewer, we included only general practitioners.

This study was approved by the Institutional Review Board of the Chest Research Foundation (CRF). The IRB waived the requirement for patient consent as this was an observational study.

Data collection

Workers from the primary-care field force of Cipla (n=716), visited the selected primary health-care practitioners, extended the invitation from the Chest

Research Foundation (CRF) to participate in this study, handed over the study related documents, collected the filled in and sealed data collection forms, and sent them to the CRF for data management and analysis.

The primary research tool used for this study was a two-page questionnaire, designed by workers at the CRF (appendix). This questionnaire captured information on the health practitioner's qualification, practice type, the city or town and state or union territory, date of data collection, and the age and sex of every patient who visited the clinic or hospital on that day. In addition, the questionnaire had a list of all symptoms and medical conditions for each organ system based on the International Classification of Diseases (ICD-10). The questionnaire contained a column for each patient who visited the doctor on the study date and the doctor marked the circle in front of the symptom or symptoms and the medical condition box (if a diagnosis was made). The questionnaire was initially pilot tested in 45 randomly selected primary health-care practitioners from three cities in India, and was found to be easy to fill and required no more than a minute to complete. No major logistical issues were identified.

Primary practitioner participants in the POSEIDON study were asked to fill out the questionnaire to record data for every patient they saw on Tuesday Feb 1, 2011. We chose this date to avoid any bias from seasonal patterns of disease (such as viral fever, infections of the gastrointestinal tract, or the upper respiratory tract) or the effect of sociocultural, religious events, or holidays on attendance. Six short text messages were sent to each participating doctor and the study team on their mobile phones (at week -4, week -2, day -1, day 0 [Feb 1], day +1, and week +1). A total of 91 310 text messages were sent. Additionally, to ensure study participation and maximise

response rates, there was coverage by the national television and print media (day 0).

Between April, 2011, and July, 2011, a team of ten data entry operators manually entered questionnaire responses using Epi-Info open source software (Centers for Disease Control and Prevention, Atlanta GA, USA). The accuracy of data entry was monitored by a data manager who did random daily cross-checks of at least 10% of questionnaires. Filled-in questionnaires of uncertain quality (eg, not done on Feb 1, 2011, had cross-gender symptoms, or had a particular pattern in marking the symptoms) were excluded.

See Online for appendix

Statistical analysis

Simple descriptive analyses were performed on the entire dataset to obtain prevalence rates for different symptoms and diseases using SPSS version 11.5. Further subgroup analysis was performed by state, gender, age, doctor's qualification, doctor's practice type, city/town's population (>1 million or <1 million). Associations between comorbid conditions were analysed using the χ^2 test to obtain odds ratios and CIs. Unadjusted p values of less than 0.0001 were considered significant to account for multiple comparisons. To understand the effect of age, pair-wise associations of symptoms in each decade of age, up to 60 years and greater, were calculated using Fisher's exact test in R (R Foundation for Statistical Computing, Vienna, Austria) and stored as edgelist. Negative logarithms of the p-values obtained (for all $p < 0.05$) were used as weights for the construction of a weighted network (relevance network) stored in a standard network format using Pajek software (Bategelj and Mrvar, Ljubljana, Slovenia). False relationships are less likely to form modules, which limits the need for multiple comparison correction. Modularity

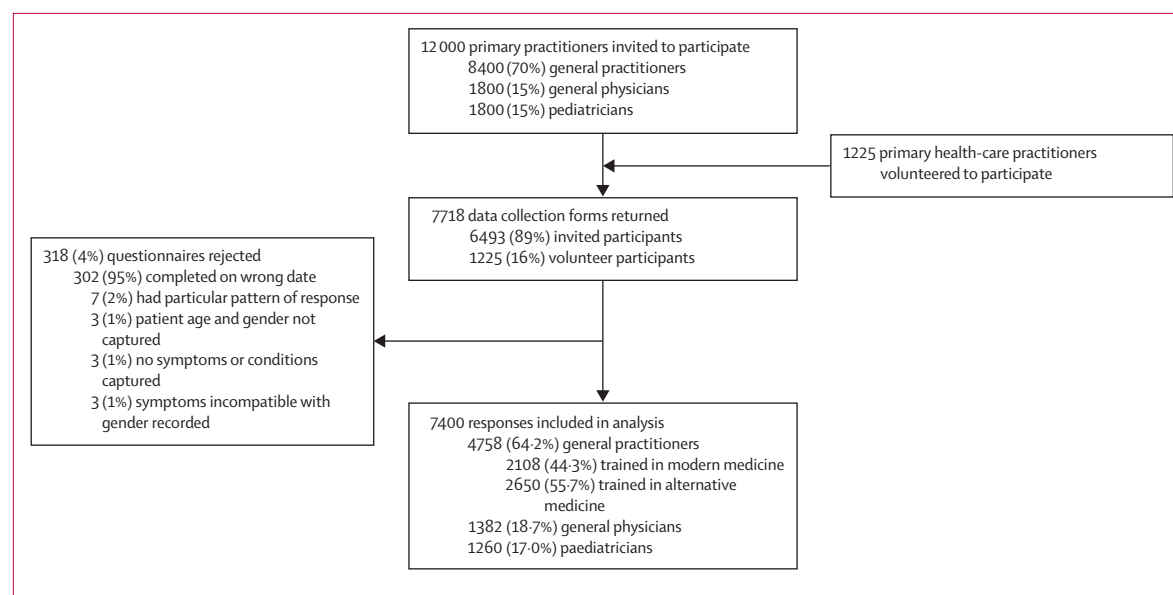


Figure 1: Study profile and respondent characteristics

detection in the network was done using the map-equation algorithm and the dynamics of the modules were represented as alluvial diagram using alluvial generator (MapEquation, Umeå, Sweden). Because of the computationally intensive analyses, we ran inhouse scripts in a parallelised mode on a super computer (SGI, USA).

Role of the funding source

Workers from the CRF, an autonomous academic research institute, designed the study, developed the questionnaire, and took part in the analyses, interpretation, and writing up of the manuscript. The Institute of Genomics and Integrated Biology, a public-funded Government body of the Council of Scientific and Industrial Research, helped in the critical analysis, interpretation, and writing up of the study. Cipla Ltd

provided the logistical support for meeting the randomly selected health-care practitioners, explaining to them the purpose and methods of the study, collecting the filled-in and sealed questionnaires from the doctors and sending them to the CRF. Members of the Cipla team were not involved in the design, analysis, and interpretation of the results, but did help in the writing of the manuscript. The corresponding author had full access to all the data and was responsible for the decision to submit for publication.

Results

We invited 12 000 primary health-care practitioners randomly selected from our database to participate in the study. We received 6493 questionnaires from invited participants (58·4% response rate). In addition to these invited participants, 1225 other primary health-care practitioners from across India volunteered to participate after they heard about this large, nationwide study from their colleagues. From this total of 7718 completed questionnaires, we excluded 318 questionnaires (mainly because they had been completed on the wrong date), leaving 7400 responses from 880 cities and towns across India included in the analysis (figure 1). Of the evaluable responses, 4758 (64·3%) were from general practitioners (either in modern medicine or alternative medicine), 1382 (18·7%) from general physicians trained in modern medicine, and 1260 (17%) from paediatricians also trained in modern medicine.

On Feb 1, 2011, the day of the POSEIDON Study, 204912 patients visited the 7400 primary health-care practitioners. Mean and median number of patients seen per practitioner were 27 (SD 17) and 25 (IQR 15–35), respectively. Of the 204912 patients seen on the study day, 142 619 (69·6% attended a private clinic, 41 802 (20·4%) attended private hospitals, and 20 491 (10%) were seen by health-care practitioners from government hospitals. These data were compatible with the 70:20:10 stratification by practice type aimed for in the study design. The number of patients seen per doctor did not vary substantially by practice type (private clinics 27·0 patients [SD 18·5]; private hospitals 28·0 patients [18·9]; government hospitals 28·7 [19·2]). Non-responders were evenly distributed between practice type and location, indicating that there was no significant responder bias in this study. The final sample was, therefore, representative of the distribution of primary health-care practitioners by geography, specialty, and practice type.

Practitioners recorded visits for more male patients (180 603 patients [53%]) than female patients, and this gender difference was especially noticeable in patients younger than 18 years, of whom 36 476 (57%) were male. Patients older than 60 years represented 7·9% (n=13675) of the patient population (figure 2).

Symptoms were broadly divided into two categories: general, and system-related or organ-related. Fever

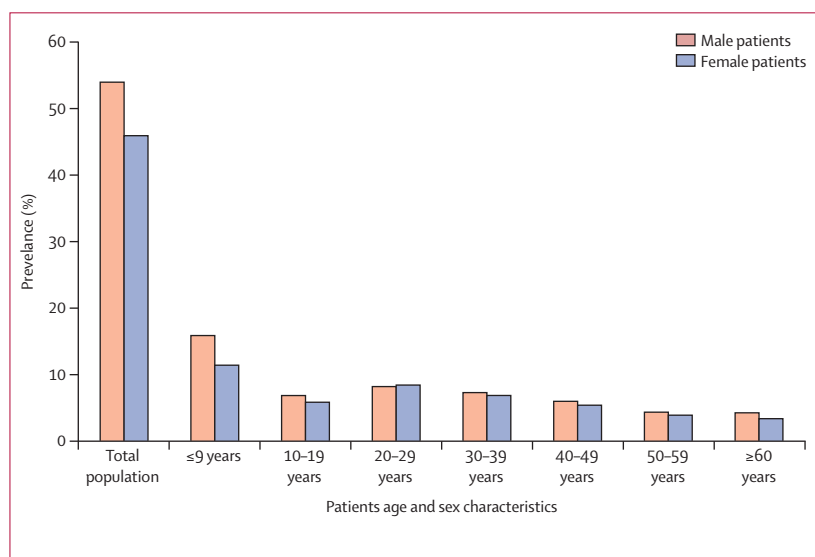


Figure 2: Patients' age and sex characteristics

$p < 0.0001$ for all male/female comparisons within age groups, apart from 20–29 years (not significant) and 30–39 years ($p = 0.0105$)

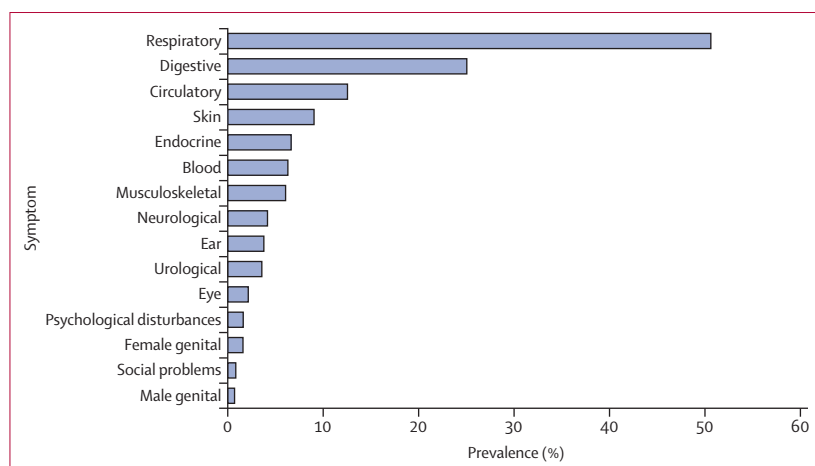


Figure 3: Reported prevalence of symptoms related to organ systems

(72785 [35.5%]), headache or body ache (39866 [19.5%]), loss of appetite (20799 [10.2%]), and accident/injury (6287 [3.1%]) were the most common general symptoms. Of patients who had fever, 6551 (9%) reported it as the only presenting symptom, 17468 [24%] reported the presence of additional general symptoms, and 48766 [67%] reported the presence of additional symptoms related to other body organs or systems (appendix).

Respiratory symptoms 103752 [50.6%]) were the main cause of a visit to a health-care practitioner, followed by digestive (51324 [25%]), circulatory (25690 [12.5%]), skin (18506 [9%]), and endocrine symptoms (13580 [6.6%]) (figure 3). Analysis by state showed that respiratory symptoms were the main reason for a visit to the doctor in all states in India, but there was no such consistent pattern for other organ systems. However, of note was that circulatory symptoms were reported more frequently by primary health-care practitioners from the eastern states of India (appendix).

Figure 4 shows the effect of increasing age on the prevalence of symptoms or diseases affecting different organs or systems and is represented as an alluvial graph. Organs and systems that have the highest prevalence of symptoms or diseases settle at the bottom of the graph and those that are less prevalent occupy the top portion. Respiratory symptoms were the most common reason for visiting a doctor for all age groups. Gastrointestinal symptoms were the second most common symptom reported up to the age of 30 years, after which they dropped to the fourth and fifth most commonly reported symptoms between 40 and 60 years of age, becoming less prevalent after the age of 60 years.

Circulatory symptoms were the fourth and fifth most common symptoms up to the age of 50 years, but became more prevalent in subsequent age groups, becoming the second most frequently reported symptom.

The alluvial graph shows not only the most prevalent symptoms and diseases but also gives a graphical representation of statistical associations between the systems, when seen as a network. These associations are represented as offshoots that connect systems, and give information about an association between two different types of symptoms or diseases. For example, symptoms related to anaemia were linked to symptoms related to female genitalia by an offshoot between 10-45 years, which disappears after 50 years of age. Similar connections were seen in the alluvial graph between male genital symptoms and urology in patients who were 50 years or older. When the association between symptoms or diseases affecting different systems is very strong, the systems may merge into a single module on the alluvial graph; without any offshoot. Such strong links were observed between endocrine and circulatory systems by around 50 years of age. However, this effect was observed only in cities and towns with a population greater than 1 million (data not shown). Key associations between age and reason for doctors visit were unchanged when considering only the data reported by modern-medicine trained health-care practitioners (appendix).

A definitive disease diagnosis was reported in 43588 (38.1%) patients seen by general practitioners, 18513 [52%] of patients seen by general physicians, and 12149 [33.7%] of patients seen by paediatricians. Overall,

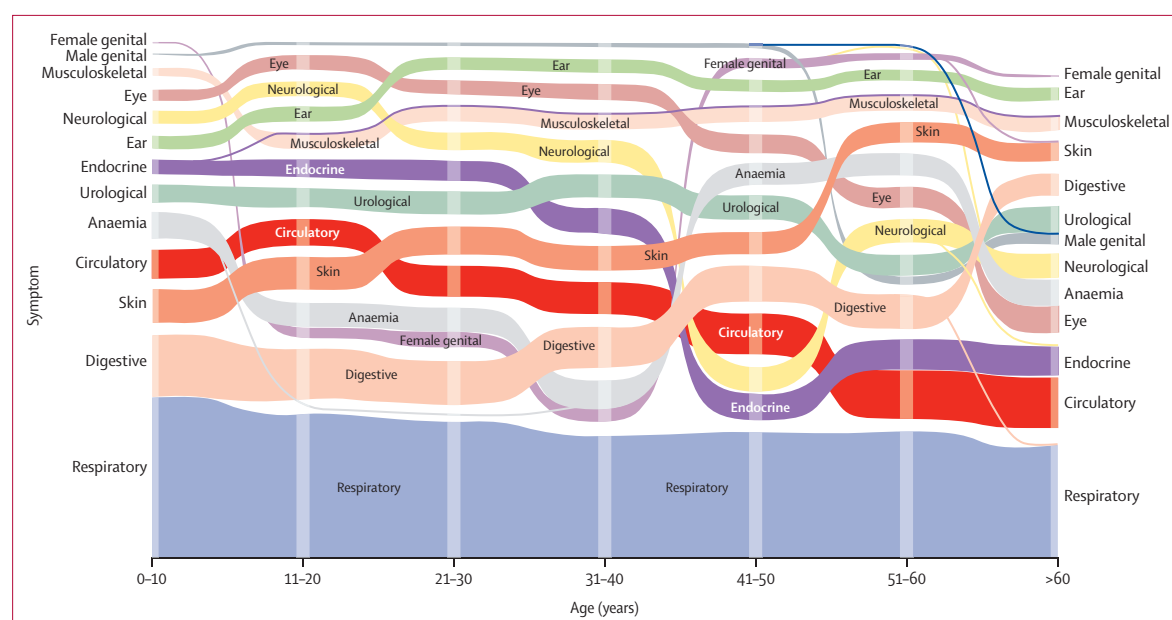


Figure 4: Alluvial graph of disease or symptom prevalence across decades of life

Width of bands corresponds to relative proportion of symptoms or medical conditions, with the y axis organised to have the most prevalent conditions closest to the x axis. Associations between symptoms or conditions are represented as offshoots that connect systems. The light shaded vertical bars correspond to the decade-wise groupings used in analysis.

	Overall (n=204 912)	Private clinic (n=142 680 [69.6%])	Private hospital (n=41 761 [20.4%])	Government hospital (n=20 471 [10.0%])
Hypertension	14.52% (14.4–14.7)	13.83% (13.6–14.1)	15.50% (15.0–16.0)	17.14% (16.4–17.9)
Obstructive airway diseases	14.51% (14.4–14.7)	14.96% (14.7–15.2)	12.69% (12.3–13.1)	15.17% (14.5–15.9)
Upper respiratory tract infections	12.96% (12.8–13.1)	13.13% (12.9–13.4)	12.00% (11.6–12.4)	13.52% (12.9–14.2)
Anaemia	10.12% (10.0–10.3)	10.70% (10.5–10.9)	9.72% (9.3–10.1)	8.48% (7.9–9.0)
Diabetes	8.85% (8.7–9.0)	8.02% (7.8–8.2)	11.25% (10.8–11.7)	9.24% (8.9–9.8)
Lower respiratory tract infections/pneumonia	7.88% (7.8–8.0)	8.6% (7.9–8.3)	7.79% (7.4–8.1)	6.34% (5.9–6.8)
Arthritis/ joint swellings	4.57% (4.5–4.7)	4.99% (4.8–5.2)	3.71% (3.5–3.95)	4.00% (3.6–4.4)
Skin itch /eczema	4.23% (4.1–4.3)	4.60% (4.4–4.8)	3.27% (3.0–3.5)	3.88% (3.5–4.2)
Skin rash	3.88% (3.8–4.0)	4.26% (4.1–4.4)	3.34% (3.1–3.6)	2.78% (2.5–3.1)
Tuberculosis	3.36% (3.3–3.4)	3.25% (3.1–3.4)	3.31% (3.1–3.5)	4.10% (3.7–4.5)
Obesity/lipid disorders	3.35% (3.3–3.4)	3.25% (3.1–3.4)	3.59% (3.3–3.8)	3.33% (3.0–3.7)
Psychological disturbances	2.97% (2.9–3.0)	3.04% (2.9–3.2)	3.08% (2.9–3.3)	2.16% (1.9–2.4)
Hepatitis	2.72% (2.7–2.8)	2.72% (2.6–2.8)	2.81% (2.6–3.0)	2.48% (2.2–2.8)
Ischaemic heart diseases	2.63% (2.6–2.7)	2.21% (2.1–2.3)	3.58% (3.3–3.8)	3.06% (2.7–3.4)
Social problems	1.53% (1.5–1.6)	1.47% (1.4–1.6)	1.70% (1.5–1.9)	1.32% (1.1–1.5)
Congestive heart failure	1.21% (1.2–1.3)	0.99% (0.92–1.06)	1.53% (1.4–1.7)	1.86% (1.6–2.1)
Stroke/cerebrovascular accidents	0.73% (0.69–0.77)	0.51% (0.46–0.57)	1.13% (0.99–1.3)	1.14% (0.9–1.3)

Data are % (95% CI)

Table: Prevalence of diseases as diagnosed by primary health-care practitioners in India, overall and by practice setting

the ten diseases diagnosed most often by primary health-care practitioners in India were: hypertension, obstructive airways diseases, upper respiratory tract infections, anaemia, diabetes, lower respiratory tract infections or pneumonia, arthritis or joint swellings, eczema, skin rash or urticaria, tuberculosis, and obesity or lipid disorders (table). The table also shows how the prevalence of these diagnoses varies by practitioner type across India.

About a fifth (21.4%) of all patients with hypertension reported by primary health-care practitioners were aged under 40 years (appendix). A diagnosis of asthma or chronic obstructive pulmonary disease (COPD) was more frequent across all age groups in patients living in cities or towns with a population of less than 1 million people than in patients in cities with a population over 1 million (appendix). Anaemia was the fourth most common disease reported and was more prevalent in female patients than boys and men (6771 [7.5%] vs 4100 [3.9%], respectively, $p<0.0001$) with the difference even more marked in women of menstruating age (9.3% in women vs 3% in men: OR 3.36 [95%CI 3.12–2.6]; $p<0.0001$) (appendix).

The average number of symptoms or medical conditions for which a patient visited a practitioner was 2.8 (SD 2.1; range 1–33). 82687 patients (40.4%) had symptoms or diseases across multiple systems or organs. Hypertension, which was the most common diagnosis reported, was strongly associated with ischaemic heart disease after adjusting for other reported comorbid conditions and for sex (adjusted OR 9.8 [95% CI 9.1–10.7]; $p<0.0001$), diabetes (6.1 [5.8–6.4]; $p<0.0001$), obesity or lipid disorders (3.7 [3.5–4.1]; $p<0.0001$), and COPD

(1.9 [1.8–2.1]; $p<0.0001$). Patients diagnosed with COPD reported the most number of comorbid associations, namely congestive heart failure (4.55 [3.8–5.4]; $p<0.0001$), ischaemic heart disease (2.65 [2.3–3.0]; $p<0.0001$), hypertension (2.12 [2.0–2.4]; $p<0.0001$), stroke (2.17, [1.6–2.9]; $p<0.0001$), diabetes (1.71 [1.5–1.9]; $p<0.0001$), arthritis or joint swellings (1.34 [1.2–1.5]; $p<0.0001$), and anaemia (1.27 [1.1–1.4]; $p<0.0001$). Asthma was strongly and positively associated with cataract (2.56 [2.1–3.0]; $p<0.0001$), social problems (1.51 [1.3–1.8]; $p<0.0001$), and hypertension (1.26 [1.2–1.4]; $p<0.0001$) and negatively associated with abdominal pain (0.47 [0.43–0.52]; $p<0.0001$).

Discussion

The POSEIDON study is a large 1-day, point-prevalence study across 880 cities and towns in India, with quite good response rates throughout the country (appendix). This study identified the main conditions that lead a patient to visit a primary health-care practitioner. Analyses of the 554146 ailments reported in 204912 patients visits have provided an insight into what ails India. The results of this study have implications for planning of health-care services and infrastructure development, design of medical education curricula, and identification of health research priorities in India.

Practice-based morbidity surveys such as the POSEIDON study provide data that are different from those of population-based health surveys because they have the unique advantage of added inputs of physician interpretation. They provide population-level sickness patterns that are valuable for deploying often limited resources available for health-care services. Several

countries have used the results of such surveys to drive public health policies. This is the first attempt at such a large nationwide study from India and sets an example of how large, meaningful, and good quality data can be generated in resource-poor settings by partnership between academia and the pharmaceutical industry.

In contrast to studies from Singapore,⁴ Sri Lanka,⁵ Malaysia,⁶ and South Africa,⁷ where more female patients visited a primary care physician, our study showed that primary practitioners received a greater proportion of visits from male patients (54.1%). This gender bias remained throughout all age groups, including children, adults in the reproductive years, and older people, and was constant across all regions of the country. In an equitable society, one would intuitively expect the child-bearing related needs of women to lead to greater use of ambulatory health care in women. Although non-inclusion of women's-health specialists might have led to an underestimate of the number of female patients, the gender difference was even larger in patients younger than 18 years (57% males). Such gender inequality is similar to that seen in other recent population-based studies⁸ and probably reflects social values surrounding male preference in India.

Furthermore, only 7.9% of patients who visited a primary health-care provider in our study were older than 60 years. The proportion of people older than 60 years is 8% in India.⁸ Since older people will suffer from age-related ailments, our findings probably reflect a reduced opportunity to seek health care compared with that for younger people. Other than infirmity, we speculate that economic reasons prevent older people from seeking health care, since 80% of health care in India is paid for by the individual, rather than the state. Supporting this observation is a finding from Agrawal and colleagues⁹ that when health-care delivery is provided free of charge and delivered near patients' homes, older people are the largest users of such care. Since women and older people have greater health needs than the rest of the population, our findings might be describing a widespread social inequality in India.

Respiratory symptoms were the leading cause of a visit to a health-care provider across India, accounting for about half of all patients and 65% of all child patients. Although infections of the upper and lower respiratory tract were among the leading causes of respiratory symptoms, asthma and COPD together captured under the category of obstructive airways diseases was the second most common diagnosis reported by primary health-care practitioners in India. Previous work by Duong and colleagues¹⁰ showed that Indians had the lowest lung function of the 17 countries that were studied, with a mean difference in spirometric indices of about 30–35% lower than white people matched for age, sex, and height. COPD was reported as the second leading cause of death in India in the 2013 Global Burden of Disease Report.¹¹ These previous studies and the results

from the POSEIDON study highlight the huge burden of both acute and chronic respiratory diseases in India and should serve as a call for urgent public health measures to reduce the burden of chronic, non-communicable respiratory diseases in India.

Although circulatory symptoms accounted for the third most common cause of a visit to a health-care provider in India, hypertension was the most common diagnosis reported by the primary health-care practitioners. More importantly, a fifth of patients with hypertension in the POSEIDON study were younger than 40 years, indicating a high burden of young patients with hypertension in India and suggesting that blood pressures be routinely measured in young adults. The diagnosis of hypertension was more commonly reported from cities and towns with a population greater than 1 million people than from those with a population less than 1 million, suggesting that hypertension is more common in overcrowded and urban places in India. The results of the POSEIDON study support the World Health Statistics Report¹² which showed that in India between 1980 and 2008, there was an increase in age-standardised prevalence of hypertension. This finding is in contrast with other regions of the world where there has, in fact, been a downward trend.

The large number of patients with more than one symptom or diagnosis gave us an opportunity to look for associations between symptoms and medical conditions across gender, age groups, and region. Symptoms form relations, which form understandable groups as related to organ-systems or origin. Importantly, such associations change with age group, with various modules aggregating or splitting at different ages, developing new relations, and changing their relative importance. The most obvious of these include the strengthening association and importance of endocrine and circulatory modules with advancing age to the point that a single module is formed by about age 45 years. Similarly, male genital and urological modules show merging from about age 60 years and older. While these associations are obvious from a medical perspective, these results show that our study design was successful in drawing a longitudinal understanding from cross-sectional point prevalence data, as was seen for menstruation-associated anaemia.

Two major types of India-wide data can be used to understand the relation between health and recorded lifestyle factors. First, discrete data pertaining to specific socioeconomic and health variables has been openly collected and shared by the Open Governance India initiative to enable participatory governance. Second, the National Family Health Survey (NFHS) captures broad socioeconomic data and health information related to fertility, infant and child mortality, practice and family planning, maternal and child health, reproductive health, nutrition, and anaemia. Although it could be expected that the detailed medical dataset from POSEIDON would usefully combine with broad nationwide data from NFHS, the dissimilarities in source and scope

For the Open Governance India initiative see <http://opengovernanceindia.org>

For India's census see
<http://www.censusindia.gov.in/2011-common/mccd.html>

make comparisons or integration difficult. Whereas POSEIDON had a focus on health and data were obtained from clinicians, the NFHS draws data from household surveys that have very few disease-related parameters. However, chronic diseases such as asthma, diabetes, and goitre were most strongly linked to each other and to age in the NFHS, consistent with what was expected and also seen in POSEIDON. Data on medical certification of cause of death are available via India's census. In 2012, however, the year for which the latest data are available, only 20% of all deaths had a medical certification and there was much heterogeneity in reporting between states. Circulatory, infectious, and respiratory diseases were the three most common causes of death.

The large number of symptoms and medical conditions (554146) also gave us a unique opportunity to look for comorbid associations in an unbiased manner. Of the highly significant associations ($p < 0.0001$), patients with COPD were more likely to have congestive heart failure, ischaemic heart disease, hypertension, stroke, diabetes, arthritis/joint swellings, and anaemia. While these associations have been reported from the UK and USA,¹³ our results show that the same association exists in India. We also noted comorbid conditions associated with asthma. Presence of asthma was strongly associated with cataract, social problems, obesity, and hypertension. Although the association between asthma and cataract has been reported elsewhere,^{14,15} the OR reported in our study is much greater and might be related to widespread use of oral steroids in asthma treatment in India. Association of asthma with components of metabolic syndrome, including hypertension, observed in our study have been reported by other researchers.^{16,17}

The POSEIDON study has several limitations. For example, the most disadvantaged sections of society, who might have difficulty in visiting primary health-care practitioners, will be under-represented in such practice surveys. Further, our choice of a single day for this study does restrict the type of potential inferences that can be made. Feb 1, the day chosen for data collection, is far from the infectious epidemic seasons, and such diseases will not be adequately represented here. Ideally, we would have repeated data collection three to four times throughout the year to enable analysis of seasonal variation in symptoms and disease. However, resource constraints and practical challenges meant that we could collect data only once.

With this first study as a proof-of-concept, we intend to repeat such studies in the future at different times of the year to better represent the dynamic nature of what ails India. The current observations, therefore, mostly pertain to chronic diseases or common year-round illnesses, and are consistent with available global and regional trends.¹ Precise comparisons with population-based studies are unfeasible because of a general lack of comparable data. As discussed previously here, nationwide NFHS data and other data reported by the

Indian Ministry of Statistics have a very different structure and design, which limits comparisons. Nevertheless, important insights of social and medical nature can be gleaned.

Another limitation is that because there is poor access to diagnostic facilities and tests in most settings in our study areas, primary health-care practitioners often base their diagnoses on a patient's medical history and clinical examination alone. It is, therefore, possible that some diagnoses are incomplete or even incorrect, which limits the conclusions that can be drawn from our data. Nevertheless, our data would be expected to be more reliable than those from household surveys and they will reflect the health challenges as they are perceived in the community.

To overcome the limitations of scarce diagnostic facilities and the absence of data from different times throughout the year, we have recently started placing eHealth Centres across India, which are technologically modern primary health-care centres that permit longitudinal documentation of the actual clinical workflow and data on a monitored health cloud that is accessible to researchers in a summarised format.⁹ The two approaches of year round collection of data from eHealth centres and point prevalence studies are complementary and should provide novel and important insights into general trends as well as those for specific diseases.

An avoidable flaw in our study was the potential for bias created by the inclusion of 1225 additional primary health-care practitioners who volunteered to participate in the study, rather than being randomly included. Such inclusion will be avoided in future studies.

Health care in India is not organised in accordance with societal needs, and it faces several challenges, such as socioeconomic inequality, inappropriate distribution of government subsidies, low emphasis on preventive services at all levels, and a lack of effective national programmes or policies for many common illnesses.¹⁸ The results of the POSEIDON study should not only help organise health-care delivery in accordance with societal needs, but also set the path for future studies in other developing countries. Resultant data could help to establish disease patterns and patient profiles, which could then influence and drive health-care services, medical research and medical education, as well as fuel innovation in health epidemiology.

Contributors

SS conceived the idea and contributed to the design, conduct, analysis, interpretation, and writing up of the manuscript. KAp coordinated the entire conduct of the study, helped in designing the research tools, and contributed to the interpretation and writing up of the manuscript. SM contributed to the study design, data management, analyses, and interpretation of the study. MB contributed to the conduct of the study, training of field workers, and writing up of the manuscript. SC contributed to the conduct of the study, training of field workers and writing up of the manuscript. TS, KAg, and AA contributed to the advanced statistical analysis, critical interpretation, and writing up of the manuscript. JG contributed to the overall conduct and writing up of the manuscript.

Declaration of interests

The study was conducted by the Chest Research Foundation (CRF; a public charitable trust), the Council of Scientific and Industrial Research—Institute of Genomics and Integrated Biology (CSIR-IGIB; a publicly funded government organisation), and Cipla Ltd (a pharmaceutical company). The Chest Research Foundation was founded by Cipla Ltd in 2002, and since 2005 has been functioning as an independent, autonomous organisation. The POSEIDON study was self-funded by each organisation and none of the authors from the CRF and CSIR-IGIB received any consultancy or participative fees from Cipla Ltd. We declare competing interests.

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