EDITORIAL

Impact of the Neglected Tropical Diseases on Human Development in the Organisation of Islamic Cooperation Nations

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The employment of a new “worm index” of human development, together with additional published health information, confirms the important role neglected tropical diseases (NTDs) play in hindering the advancement of many of the world’s Muslim-majority countries.

The Organisation of Islamic Cooperation (OIC, previously the Organisation of the Islamic Conference) is the major inter-governmental organization of 57 Muslim-majority countries, with a mission to promote human rights (especially those of children, women, and the elderly), education, trade, and good governance (Fig 1) [1]. Under the OIC charter, the advancement of science and technology through cooperative research is also a key component [1,2]. In 2009, one of us (PJH) reviewed the available data on the major NTDs and found that many of these diseases disproportionately affected OIC countries, particularly the poorest nations of the Sahel and elsewhere in sub-Saharan Africa and Asia [3]. A previous survey of the 28 largest OIC nations—each with a population of at least 10 million people and comprising more than 90% of the populations of the OIC—found that they accounted for 35%–40% of the world’s soil-transmitted helminth infections and 46% of cases of schistosomiasis, in addition to approximately 20% of the cases of trachoma and leprosy [3]. Given the known impact of these NTDs on both public health and socioeconomic development, it was recommended that scale-up of mass treatment for these diseases should commence in the most affected OIC nations [3]. However, we find that it has been difficult to make progress against poverty and NTDs in the OIC nations.

Today, through support of the United States Agency of International Development’s (USAID) NTD Program, national efforts to control or eliminate NTDs through mass treatments are underway in eight sub-Saharan African OIC countries, in addition to Bangladesh and Indonesia [4]. Efforts are also underway through the NTD Programme of the United Kingdom Department for International Development (UK DFID) [5], while the END Fund, a private philanthropic initiative, supports programs in sub-Saharan African OIC countries, including Nigeria, Niger, and Mali, as well as Yemen, which also receives NTD program support from the World Bank [6].

An updated review and “scorecard” confirm widespread poverty and disease remaining among the 30 most populated OIC countries—those with populations approaching 10 million people or more, and comprising more than 90% of the estimated 1.6 billion people living in these countries (Table 1) [7–9]. At least 40% of the four largest Muslim-majority countries...
(Indonesia, Pakistan, Nigeria, and Bangladesh) with a combined population of almost 800 million people [7] live on less than US$2 per day [8]. Moreover, while nine of the 30 OIC countries have United Nations Development Programme (UNDP) human development indices (HDIs) in the "high" or "very high" category, 14 are in the "low" category, with some Sahelian OIC nations, such as Burkina Faso, Cameroon, Chad, Mali, Niger, Senegal, and Sudan ranking at or near the bottom of the UNDP's list of HDIs [9].

Based on information from the Preventive Chemotherapy and Control (PCT) database of the World Health Organization (WHO) updated in 2014, helminthic NTDs are still widespread among the OIC countries [10–15]. As shown in Table 2, while the combined population of the 30 most-populated OIC countries of 1.56 billion people accounts for approximately 20% of the global population, it accounts for 37% of school-aged children requiring annual deworming for their intestinal helminth infections [10, 11] and 50% of school-aged children requiring preventive chemotherapy (PC) treatments for schistosomiasis [12, 13]. These OIC nations also account for one-third of the global population requiring PC for lymphatic filariasis (LF) [14, 15].

Such data can be used to calculate a “worm index” of human development in which the number of school-aged children requiring PC for both intestinal helminth and schistosomiasis is added to the population requiring PC for LF, and then divided by the total population of a given nation [16]. It was found previously for the world’s 25 most populated countries that as
the HDI fell into the medium range below 0.700, the worm index began to increase sharply towards 0.400; there was a significant rise in the worm index toward 1.000 as the HDI fell into the low range, below 0.500 [16]. As shown in Fig 2, this inverse relationship between HDI and worm index is also true of the OIC countries (R = -0.85 and \( p < 0.0001 \)). Remarkably, none of the OIC countries had an HDI over 0.85. The highest worm indices are among Sahelian nations, followed by other sub-Saharan African countries, and then the large Muslim-majority countries of Asia. Overall, the mean worm index of OIC countries (0.445) was substantially higher than our global estimates (0.270).

The links between intestinal helminth infections and schistosomiasis among school-aged children and human development were summarized previously, and include effects on childhood growth and cognition; similarly, there are links between LF and productive capacity [16].

### Table 1. Economic indicators of the 30 most populated OIC countries.

| Rank | Country       | Population [7] | Living on <US$2 per day | Human Development Index (HDI) [9] | HDI Classification | HDI Rank |
|------|---------------|----------------|--------------------------|-----------------------------------|--------------------|----------|
| 1    | Indonesia     | 253 million    | 43.3% (2011)             | 0.684                             | Medium             | 108      |
| 2    | Pakistan      | 185 million    | 50.7% (2011)             | 0.537                             | Low                | 146      |
| 3    | Nigeria       | 179 million    | 82.2% (2010)             | 0.504                             | Low                | 152      |
| 4    | Bangladesh    | 159 million    | 76.5% (2010)             | 0.558                             | Medium             | 142      |
| 5    | Egypt         | 83 million     | 15.4% (2008)             | 0.682                             | Medium             | 110      |
| 6    | Iran          | 78 million     | 8% (2005)                | 0.749                             | High               | 75       |
| 7    | Turkey        | 76 million     | 2.6% (2011)              | 0.759                             | High               | 69       |
| 8    | Algeria       | 40 million     | N.R. a                   | 0.717                             | High               | 93       |
| 9    | Uganda        | 39 million     | 62.9% (2013)             | 0.484                             | Low                | 164      |
| 10   | Sudan         | 39 million     | 44.1% (2009)             | 0.473                             | Low                | 166      |
| 11   | Iraq          | 35 million     | 21.2% (2012)             | 0.642                             | Medium             | 120      |
| 12   | Morocco       | 33 million     | 14.2% (2007)             | 0.617                             | Medium             | 129      |
| 13   | Afghanistan   | 31 million     | N.R.                     | 0.468                             | Low                | 169      |
| 14   | Malaysia      | 30 million     | 2.3% (2009)              | 0.773                             | High               | 62       |
| 15   | Saudi Arabia  | 29 million     | N.R.                     | 0.836                             | Very High          | 34       |
| 16   | Uzbekistan    | 29 million     | N.R.                     | 0.661                             | Medium             | 116      |
| 17   | Mozambique    | 26 million     | 82.5% (2009)             | 0.393                             | Low                | 178      |
| 18   | Yemen         | 25 million     | 37.3% (2005)             | 0.500                             | Low                | 154      |
| 19   | Cameroon      | 23 million     | 53.2% (2007)             | 0.504                             | Low                | 152      |
| 20   | Syria         | 22 million     | N.R.                     | 0.658                             | Medium             | 118      |
| 21   | Cote d'Ivoire | 21 million     | 59.4% (2008)             | 0.452                             | Low                | 171      |
| 22   | Niger         | 19 million     | 76.1% (2011)             | 0.337                             | Low                | 187      |
| 23   | Burkina Faso  | 17 million     | 72.4% (2009)             | 0.388                             | Low                | 181      |
| 24   | Kazakhstan    | 17 million     | 0.8% (2010)              | 0.757                             | High               | 70       |
| 25   | Mali          | 16 million     | 78.8% (2010)             | 0.407                             | Low                | 176      |
| 26   | Senegal       | 15 million     | 60.3% (2011)             | 0.485                             | Low                | 163      |
| 27   | Chad          | 13 million     | 60.5% (2011)             | 0.372                             | Low                | 184      |
| 28   | Tunisia       | 11 million     | 4.5% (2010)              | 0.721                             | High               | 90       |
| 29   | Azerbaijan    | 10 million     | 2.4% (2008)              | 0.747                             | High               | 76       |
| 30   | United Arab Emirates | 09 million | N.R.                   | 0.827                             | Very High          | 40       |
|      | Total for OIC all countries | 1.56 billion |                      |                                   |                    |          |

\( a = \) Not reported between years 2005 and 2013

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Beyond helminth infections used to calculate the worm index of human development, as shown in Table 3, the major OIC countries also account for 44% of the global population at risk for onchocerciasis, mostly those in the Sahel and Yemen [17]. Moreover, 68% of the incident cases of cutaneous leishmaniasis (CL) occur in OIC countries, especially those in the Middle East and North Africa [18]. Among the bacterial NTDs, OIC countries account for almost 20% of the world’s registered leprosy cases [19], while trachoma is an important disease in the

| Country          | School-aged children requiring annual deworming for their intestinal helminth infections [10] | School-aged children requiring preventive chemotherapy treatments for schistosomiasis [12] | Populations requiring preventive chemotherapy for lymphatic filariasis [14] | Total helminths (adding three categories) | Worm Index [16] |
|------------------|-------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------|----------------|
| Indonesia        | 48.3 million                                                                                   | <0.1 million                                                                               | 99.7 million                                                             | 148.0 million                             | 0.585          |
| Pakistan         | 21.2 million                                                                                   | Not endemic                                                                                | Not endemic                                                              | 21.2 million                              | 0.115          |
| Nigeria          | 46.4 million                                                                                   | 23.2 million                                                                               | 114.3 million                                                            | 183.9 million                             | 1.027          |
| Bangladesh       | 31.8 million                                                                                   | Not endemic                                                                                | 49.7 million                                                             | 81.5 million                              | 0.513          |
| Egypt            | No PC required                                                                                 | 0.1 million                                                                                | 0.6 million                                                              | 0.7 million                               | 0.008          |
| Iran             | Not reported                                                                                  | Not endemic                                                                                | Not endemic                                                              | 0                                         | 0              |
| Turkey           | No PC required                                                                                 | Not endemic                                                                                | Not endemic                                                              | 0                                         | 0              |
| Algeria          | Not reported                                                                                  | Not endemic                                                                                | Not endemic                                                              | 0                                         | 0              |
| Uganda           | 11.1 million                                                                                  | 4.1 million                                                                                | 14.9 million                                                             | 30.1 million                              | 0.772          |
| Sudan            | 9.9 million                                                                                   | 4.7 million                                                                                | 19.9 million                                                             | 34.5 million                              | 0.885          |
| Iraq             | 1.4 million                                                                                   | No PC required                                                                              | Not endemic                                                              | 1.4 million                               | 0.040          |
| Morocco          | Not reported                                                                                  | Not endemic                                                                                | Not endemic                                                              | 0                                         | 0              |
| Afghanistan      | 9.4 million                                                                                   | Not endemic                                                                                | Not endemic                                                              | 9.4 million                               | 0.303          |
| Malaysia         | No PC required                                                                                 | Not endemic                                                                                | 0.7 million                                                              | 0.7 million                               | 0.023          |
| Saudi Arabia     | Not reported                                                                                  | No PC required                                                                              | Not endemic                                                              | 0                                         | 0              |
| Uzbekistan       | 0.3 million                                                                                   | Not endemic                                                                                | Not endemic                                                              | 0.3 million                               | 0.010          |
| Mozambique       | 7.3 million                                                                                   | 5.2 million                                                                                | 17.7 million                                                             | 30.2 million                              | 1.162          |
| Yemen            | 6.3 million                                                                                   | 2.9 million                                                                                | Undergoing surveillance                                                 | 9.2 million                               | 0.368          |
| Cameroon         | 5.9 million                                                                                   | 3.6 million                                                                                | 17.1 million                                                             | 26.6 million                              | 1.157          |
| Syria            | Not reported                                                                                  | Not endemic                                                                                | Not endemic                                                              | 0                                         | 0              |
| Cote d'Ivoire    | 5.2 million                                                                                   | 2.4 million                                                                                | 17.4 million                                                             | 25.0 million                              | 1.190          |
| Niger            | 5.2 million                                                                                   | 3.0 million                                                                                | 12.6 million                                                             | 20.8 million                              | 1.095          |
| Burkina Faso     | 4.7 million                                                                                   | 1.8 million                                                                                | 13.1 million                                                             | 19.6 million                              | 1.153          |
| Kazakhstan       | Not reported                                                                                  | Not endemic                                                                                | Not endemic                                                              | 0                                         | 0              |
| Mali             | 4.3 million                                                                                   | 2.4 million                                                                                | 17.3 million                                                             | 24.0 million                              | 1.500          |
| Senegal          | 3.8 million                                                                                   | 1.9 million                                                                                | 8.1 million                                                             | 13.8 million                              | 0.920          |
| Chad             | 3.7 million                                                                                   | 1.8 million                                                                                | 7.3 million                                                             | 12.8 million                              | 0.985          |
| Tunisia          | 0.1 million                                                                                   | Not endemic                                                                                | Not endemic                                                              | 0.1 million                               | 0.009          |
| Azerbaijan       | 0.2 million                                                                                   | Not endemic                                                                                | Not endemic                                                              | 0.2 million                               | 0.020          |
| United Arab Emirates | Not reported                                                                                   | Not endemic                                                                                | Not endemic                                                              | 0                                         | 0              |
| Total for OIC all countries | 226.5 million                                                                                   | 57.1 million                                                                               | 410.4 million                                                            | 694 million                               | 0.445          |
| Globally | 609.5 million in 2012 [11]                                                                 | 114.3 million in 2012[13]                                                                | 1,241.9 million in 2013 [15]                                             | 1,965.7 million                           | 0.270          |
| Percentage in 30 leading OIC countries | 37%                                                                                           | 50%                                                                                       | 33%                                                                      | 35%                                       |                |

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Sahelian and other OIC countries [20,21]. Of the 30 most populated OIC countries, only 11 are considered by WHO to be non-endemic for trachoma [20,21].

The findings of widespread endemic NTDs, including the major helminth infections, CL, and trachoma, have important implications for the overall development of the world’s most populated OIC countries. In addition to their impact on human development, these NTDs actually promote poverty because of their chronic and debilitating effects, especially on women and children [22,23].

It is important for all nations to respond to diseases of poverty, such as NTDs. In recognition of this, the United Nations has incorporated the elimination of NTDs into their new Sustainable Development Goals. The NTDs are also important because of their potential to emerge or re-emerge in the setting of conflict and post-conflict situations, as we have seen in Africa and the Middle East [24,25]. Therefore, the leadership of the OIC may wish to further emphasize targeting the NTDs for control and elimination, along the lines of the 2012 London Declaration for NTDs and a 2013 World Health Assembly resolution [26,27].

Based in part on a recent survey of experts [28], the control and elimination of NTDs will require both a scale-up of global and integrated mass treatment programs, as well as the advancement of new technologies for NTDs [29]. Given that the charter of the OIC includes scientific cooperation and advancing technologies, such efforts are within its scope. The Islamic Academy of Sciences founded in 1986 could be a key arm for the OIC in this activity [30]. Potential partners include programs such as the US Science Envoy Program, created by the White House and State Department under the Obama administration in order to reach out

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**Figure 2.** HDI versus worm index of OIC countries (R = -0.85 and p < 0.0001). doi:10.1371/journal.pntd.0003782.g002

![figure](https://example.com/figure.png)
scientifically to OIC countries through science and vaccine diplomacy, as well as programs like the NTD Support Center, established by the Task Force for Global Health, which works with communities to address the challenges associated with implementing effective NTD elimination strategies [31,32]. Together, such scientific cooperation could produce a new generation of “antipoverty” drugs, diagnostics [33], and vaccines in order to combat the major NTDs now affecting selected OIC countries as well as other nations trapped in poverty.

Table 3. Other major neglected tropical diseases.

| Country       | Population at risk for onchocerciasis in 2013 [17] | Incident cases of cutaenous leishmaniasis [18] | Leprosy registered prevalence in 2013 [19] | Trachoma in 2012 [20,21] |
|---------------|---------------------------------------------------|---------------------------------------------|-------------------------------------------|------------------------|
| Indonesia     | 0                                                 | 0                                           | 19,730                                    | Non-endemic            |
| Pakistan      | 0                                                 | 21,700 to 35,700                            | 657                                       | Endemic                |
| Nigeria       | 50.1 million                                     | 30 to 50                                    | 3,626                                     | Endemic                |
| Bangladesh    | 0                                                 | 0                                           | 3,087                                     | Non-Endemic            |
| Egypt         | 0                                                 | 1,300 to 2,200                              | N.R.                                      | Endemic                |
| Iran          | 0                                                 | 69,000 to 113,300                           | 19                                        | Surveillance           |
| Turkey        | 0                                                 | 6,900 to 11,300                             | No information                            | Non-endemic            |
| Algeria       | 0                                                 | 123,300 to 202,600                          | No information                            | Endemic                |
| Uganda        | 4.3 million                                      | 0                                           | N.R.                                      | Endemic                |
| Sudan         | 0.4 million                                      | 15,000 to 40,000                            | 1,386                                     | Endemic                |
| Iraq          | 0                                                 | 8,300 to 16,500                             | 3                                         | Surveillance           |
| Morocco       | 0                                                 | 9,600 to 15,800                             | 37                                        | Surveillance           |
| Afghanistan   | 0                                                 | 113,100 to 226,200                          | 44                                        | Endemic                |
| Malaysia      | 0                                                 | 0                                           | 353                                       | Non-endemic            |
| Saudi Arabia  | 0                                                 | 9,600 to 15,800                             | 4                                         | Non-endemic            |
| Uganda        | 0                                                 | 710 to 1,400                                | No information                            | Non-endemic            |
| Mozambique    | 0.1 million                                      | 0                                           | N.R.                                      | Endemic                |
| Yemen         | 0                                                 | 3,000 to 6,000                              | 425                                       | Endemic                |
| Cameroon      | 8.8 million                                      | 280 to 550                                  | 419                                       | Endemic                |
| Syria         | 0                                                 | 64,100 to 105,300                           | N.R.                                      | Non-endemic            |
| Cote d’Ivoire| 2.3 million                                      | 5 to 10                                     | 932                                       | Endemic                |
| Niger         | No PC required                                   | No data                                     | 375                                       | Endemic                |
| Burkina Faso  | 0.2 million                                      | No data                                     | 250                                       | Endemic                |
| Kazakhstan    | 0                                                 | 40 to 70                                    | No information                            | Non-endemic            |
| Mali          | 5.1 million                                      | 290 to 580                                  | 276                                       | Endemic                |
| Senegal       | 0.2 million                                      | 40 to 80                                    | 404                                       | Endemic                |
| Chad          | 2.5 million                                      | No data                                     | 378                                       | Endemic                |
| Tunisia       | 0                                                 | 21,400 to 35,100                            | 0                                         | Non-endemic            |
| Azerbaijan    | 0                                                 | 50 to 80                                    | No information                            | Non-endemic            |
| United Arab Emirates | 0 | 0 | 0 | Non-endemic |
| Total for all countries | 74.0 million | 467,745 to 828,620 | 32,405 | 
| Globally | 169.2 million | 690,900 to 1,213,300 | 180,618 |
| Percentage in the 30 OIC countries | 44% | 68% | 18% |

a No reported data available
b No information presented by WHO
c There may be fewer than 1 million people at risk in Yemen, but this number is not reported by the WHO

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