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Special report

Eliminating morbidity caused by neglected tropical diseases by 2030

Theresa Gyorkos,[1] Ruben Nicholls,[2] Antonio Montresor,[3] Ana Luciañez,[2] Martin Casapia,[4] Kariane St-Denis,[1] Brittany Blouin,[1] and Serene Joseph[1]

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ABSTRACT The objective of this manuscript is to provide selective examples of the work of the Pan American Health Organization/World Health Organization (PAHO/WHO) Collaborating Centre for Research and Training in Parasite Epidemiology and Control which contribute to the WHO goal of eliminating neglected tropical diseases by 2030. This PAHO/WHO CC specifically aligns its activities with the Sustainable Development Goals and with the goals outlined in the WHO Road Map for Neglected Tropical Diseases 2021-2030. Its role is to contribute to advancing global action on NTDs, primarily through policy development and knowledge translation. Three important projects have recently been completed: 1. Finalizing the Monitoring and Evaluation Framework for the NTD Road Map (published May 2021; this PAHO/WHO CC was a member of the working group); 2. Developing new guidelines for the preventive chemotherapy of *Taenia solium* taeniasis (published September 2021; this PAHO/WHO CC was co-Chair; and 3. Formulating a policy brief on deworming for adolescent girls and women of reproductive age (published January 2022; this PAHO/WHO CC is co-lead). These projects are the result of the integration of expertise and experience from multiple partners, including from PAHO and WHO (where both organizations provided key leadership), this PAHO/WHO CC, government ministries, civil society organizations and universities, among others. In conclusion, this PAHO/WHO CC contributes timely guidance to country-led evidence-informed public health policy, to cost-effective program implementation and to the identification of priority research topics – all focused, ultimately, on eliminating NTD-attributable morbidity by 2030.

Keywords Parasitic diseases; health surveillance system; women; poverty; child.

The Pan American Health Organization/World Health Organization (PAHO/WHO) Collaborating Centre for Research and Training in Parasite Epidemiology and Control at McGill University in Montreal, Canada (CAN-88) was established in 2015 to provide technical support to the Pan American Health Organization (PAHO) and the World Health Organization (WHO) in the area of the neglected tropical diseases (NTDs) (referred to as Neglected Infectious Diseases (NIDs) in the Region of the Americas) – and primarily in the soil-transmitted helminthiases (STHs) (1). This CC is notable for its expertise in epidemiology and biostatistics. Its work has been informed by a long-standing research partnership with colleagues in the Amazon region of Peru. Its workplan focuses on three major activities: 1. Training and research relevant to parasite prevention and control; 2. Knowledge dissemination - Publications and documents of the Department of Control of Neglected Tropical Diseases, at the request of PAHO/WHO; and 3. Development of policies and strategies to control STHs in women of reproductive age.

[1] PAHO/WHO Collaborating Centre for Research and Training in Parasite Epidemiology and Control, Faculty of Medicine and Health Sciences, McGill University, Montreal, Canada. ✉ Theresa Gyorkos, theresa.gyorkos@mcgill.ca
[2] Pan American Health Organization, Washington D.C., United States of America
[3] World Health Organization, Geneva, Switzerland
[4] Universidad Nacional de la Amazonia, Iquitos, Peru

TABLE 1. WHO's list of 20 neglected tropical diseases

Buruli ulcer[1]	Foodborne trematodiases[2]	Mycetoma, chromoblastomycosis and other deep mycoses[4]	Soil-transmitted helminthiases[2]
Chagas disease[2]	Human African trypanosomiasis[2]	Onchocerciasis[2]	Snakebite envenoming[6]
Dengue and chikungunya[3]	Leishmaniasis[2]	Rabies[3]	Taeniasis/ Cysticercosis[2]
Dracunculiasis[2]	Leprosy[1]	Scabies[5]	Trachoma[1]
Echinococcosis[2]	Lymphatic filariasis[2]	Schistosomiasis[2]	Yaws and other treponematoses[1]

[1] diseases caused by bacteria; [2] diseases caused by parasites; [3] diseases caused by viruses; [4] some mycoses are caused by bacteria and some by fungi; [5] disease caused by ectoparasites; [6] disease caused by toxins. This table is based on information provided by WHO (13).

The NTDs are a cluster of 20 communicable diseases which affect between 1 and 2 billion people living mostly in tropical and sub-tropical countries of the world, including all countries of Latin America and the Caribbean (2) (Table 1). Most of these diseases are life-threatening (e.g. dengue); many are zoonotic (e.g. echinococcosis); some are acute (e.g. snakebite envenoming); some are chronic (e.g. lymphatic filariasis); some can be acquired congenitally (e.g. Chagas disease); many create mental anguish and stigma (e.g. leprosy); and *all* are diseases of poverty. Impoverished people living in NTD-endemic areas not only commonly suffer from multiple diseases at the same time but, because malnutrition and other comorbidities are too often also present, they are at risk of developing health deficits which can extend over their entire lifespan (3,4).

These diseases have been called 'neglected' because they typically affect impoverished populations; they are not considered as public health priorities; their occurrence, and attributable morbidity, are underreported; and they fail to attract adequate funding or research attention (5). Global advocacy efforts are beginning to remedy this neglect (5,6). A turning point was likely the January 2012 London Declaration where key advocates from donor organizations, non-governmental organizations, academia, endemic countries and the pharmaceutical industry came together to redress the considerable and overt inequity resulting from NTDs suffered by 'the bottom billion' (7,8). At the following 2013 World Health Assembly, Resolution 66.12 was adopted, which aimed at supporting Member States in meeting targets set in 2015 and 2020 for the prevention, control, elimination and eradication of NTDs (9). In 2016, PAHO developed a robust elimination plan of action for NTDs and, importantly, included consideration of programming post-elimination (10). This was followed, in 2019, by a comprehensive policy on communicable disease elimination focusing on integration and sustainability (11).

NTDs are now explicitly included in Sustainable Development Goal (SDG) 3: Ensure healthy lives and promote well-being for all at all ages; Target 3.3: By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, waterborne diseases and other communicable diseases (12). The indicator designated for tracking the progress of action in reducing the disease burden of NTDs is: the number of people requiring intervention against NTDs. This indicator encompasses both curative aspects of interventions and preventive approaches which aim to reduce NTD-attributable morbidity and mortality. More recently, in 2021, WHO set out a new Road Map for NTDs – to end the neglect by 2030 (13). In celebrating World Day for NTDs in January 2022, PAHO encouraged governments to ensure timely treatment for persons suffering from NTDs (14).

The PAHO/WHO Collaborating Centre for Research and Training in Parasite Epidemiology and Control (CAN-88) has been actively engaged in contributing to the NTD elimination goals of PAHO and WHO. Activities include participation in webinars, in working groups, in expert advisory groups, and in research projects. Documents and video recordings are shared within the PAHO and WHO communities, in addition to being made accessible in the public domain. The following is a description of three recent contributions of the Collaborating Centre.

CONTRIBUTION 1: ON THE NTD ROAD TO 2030: MONITORING, EVALUATION AND RESEARCH

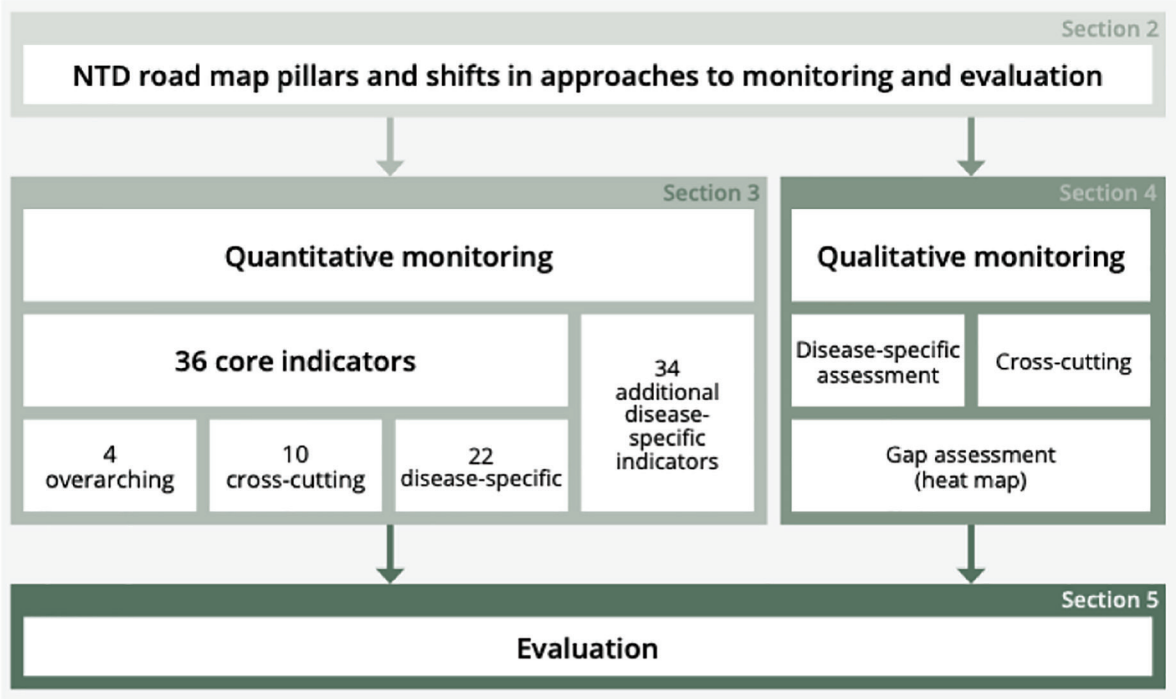
With the renewal of the NTD Road Map in 2021, it became essential to rethink how progress toward the new goals would be monitored and evaluated. New emphasis was placed on measuring impact, holistic and integrated programming, and country ownership. A comprehensive framework was developed with input from several centres and experts, including the PAHO/WHO CC on Research and Training in Parasite Epidemiology and Control (as a member of the Working Group on Monitoring, Evaluation and Research of the WHO Strategic and Technical Advisory Group for NTDs) (15). Unique to this framework was the inclusion of qualitative monitoring, in addition to the more traditional quantitative-focused monitoring. The quantitative monitoring component is based on progress obtained from 70 core and disease-specific goal-driven indicators, and the qualitative component is based on an assessment of gaps and challenges encountered in meeting the goals (Figure 1).

The core indicators include a set of 4 overarching indicators, 10 cross-cutting indicators and 22 disease-specific indicators. An additional 34 disease-specific indicators ensure that a comprehensive and timely reporting would assist with any key disease-specific attributes. To also ensure that reporting would be standardized, an NTD Compendium of Indicators was drawn up, with definitions and details on data collection, including specification of reporting tools and projected timelines (16).

The qualitative monitoring component aims to supplement the quantitative monitoring by identifying gaps or barriers to implementation so that timely solutions can be found and delays in achieving program milestones can be minimized. The Gap Assessment Tool is currently being developed to provide standardized assessment criteria for monitoring all 20 NTDs, in addition to criteria for 11 pan-disease dimensions (e.g. advocacy and logistics, diagnostics).

As the periodic quantitative and qualitative assessments will inform both progress achieved and challenges remaining, research priorities can be identified, and strategic funding opportunities and research partnerships initiated. In this way, research results can more directly inform subsequent program implementation and overall progress towards the NTD road map goals.

FIGURE 1. Essential elements of the Monitoring and Evaluation Framework of the WHO NTD Road Map for 2021-2030 (15)



This figure is reproduced from WHO (15).

CONTRIBUTION 2: PUTTING *TAENIA SOLIUM* TAENIASIS ON THE MAP

Among the NTDs, *Taenia solium* taeniasis can certainly still be regarded as neglected. This is because the disease caused by its larval form, the cysticercus (i.e. cysticercosis), and the disease named for its most important pathologic manifestation (i.e. neurocysticercosis), attract much more attention. Yet, by eliminating *Taenia solium* taeniasis, cysticercosis would quickly disappear. Prevention and control efforts for taeniasis are therefore critical to the elimination of both diseases. Because taeniasis is a zoonotic parasite disease, a One Health approach is required. In 2019, PAHO launched a manual and virtual course, in Spanish, on taeniasis and cysticercosis control highlighting the One Health approach and emphasizing interventions which could be applied to the human population, the animal population and the environment (17,18).

One of the essential elements in the control of *T. solium* taeniasis is preventive chemotherapy (PC) of at-risk human populations. In order to consolidate research and practice evidence to date, and to provide up-to-date guidance on the use of PC drugs, PAHO initiated the process of developing a guideline specifically for the use of these drugs in humans (19). The PAHO/WHO CC for Research and Training in Parasite Epidemiology and Control participated in this process. Table 2 provides the consensus recommendations which were published in 2021.

Several benefits accrue during the process of developing a guideline. First among these is typically the completion of a timely systematic review and, if warranted, a meta-analysis. This was the case here (20). In addition, the Guideline Development Group benefited not only from having advice and input from experts around the globe (e.g. researchers, methodologists, veterinarians, clinicians, program managers) but also from experts in the guideline development process itself. This resulted in a rigorous and comprehensive final product. Lastly, a robust listing of research gaps and challenges was made to draw attention to existing inadequacies in terms of diagnostics, PC implementation and delivery issues, efficacy and safety concerns, and assessment procedures. In this way, the research

TABLE 2. Recommendations regarding drugs* used in public health preventive chemotherapy (PC) programs for the control of *Taenia solium* taeniasis in endemic populations (19)

Recommendation[1]	Drug used for PC	Dosage	Conditions
1	niclosamide	2 g	Dosage adjusted for children
2	praziquantel	10 mg/kg	Reporting system is required with active surveillance and medical referral of neurological adverse events
3	albendazole	400 mg/d for 3 d	To be used only if no other alternative is available, and only if a reporting system with active surveillance and medical referral of neurological adverse events is in place

*The choice of drug depends on a number of local and national factors. The Guideline should be consulted for specific information.
[1]The use of all three drugs as a public health intervention is conditional because the evidence was assessed to be of very low certainty.
This table is based on material published by PAHO (19).

community at large could be engaged and the evidence base for subsequent guideline updates expanded.

CONTRIBUTION 3: PICKING UP THE PACE FOR THE GLOBAL ELIMINATION OF STH MORBIDITY

The soil-transmitted helminthiases (STHs) (i.e. ascariasis, hookworm disease and trichuriasis) are the most prevalent of the NTDs, occurring in over 100 countries worldwide, including Latin America and the Caribbean (Figure 2) (Table 3) and carry the largest disease burden in terms of disability-adjusted life years lost (DALYs) (21,22). This cluster of intestinal helminth diseases has long been a focus of public health action for PAHO; and many countries in Latin America and the Caribbean have national deworming days, and even weeks (23,24).

Since 2001, with Member States at the World Health Assembly (WHA) endorsing WHA Resolution 54.19, deworming programs have been implemented, focusing initially on school-age children, to effectively use the infrastructure provided by schools in endemic countries (25,26). Donations of albendazole from GlaxoSmithKline and of mebendazole from Johnson & Johnson were key to scaling up these programs with the goal of reaching 600 000 000 school-age children, per year, worldwide (21,27). Guidance subsequently followed for extending deworming treatment to preschool-age children and, indeed, to all at-risk groups (28,29).

This PAHO/WHO Collaborating Centre has been engaged in supporting the implementation of school-based deworming programs and in building up the scientific knowledge base on the impact of STH infections on health. For example, a partnership with the Dirección Regional de Salud in Loreto, Peru

FIGURE 2. Countries in the Region of the Americas where preschool-age and school-age children required preventive chemotherapy for soil-transmitted helminthiases in 2020

Countries reporting children receiving preventive chemotherapy for soil-transmitted helminthiases.

Countries not reporting children receiving preventive chemotherapy for soil-transmitted helminthiases
Data from the Global Health Observatory, World Health Organization (accessed 14 April, 2022).

Note: The designations employed and the presentation of material on this manuscript do not imply the expression of any opinion on the part of the PAJPH nor PAHO concerning the legal status of any country, territory, area, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The term "country" as used in this manuscript also refers, as appropriate, to territories or areas. The depiction and use of boundaries, geographic names and related data shown on the map and included in lists or tables are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by PAHO or its Member States.

TABLE 3. Numbers of preschool-age (PSAC) and school-age children (SAC) requiring preventive chemotherapy (PC) for soil-transmitted helminthiases (STHs) in 2020, Region of the Americas. Global Health Observatory, World Health Organization. (https://www.who.int/data/gho/data/themes/topics/soil-transmitted-helminthiases, accessed April 14, 2022)

Country	Number of PSAC and SAC requiring PC for STH
Antigua and Barbuda	1 207
Argentina	161 306
Bahamas	0
Barbados	0
Belize	0
Bolivia	189 597
Brazil	9 615 476
Canada	0
Chile	0
Colombia	3 237 824
Costa Rica	0
Cuba	48 144
Dominica	399
Dominican Republic	2 612 634
Ecuador	0
El Salvador	1 416 732
Grenada	0
Guatemala	5 052 069
Guyana	204 303
Haiti	1 136 927
Honduras	2 210 111
Jamaica	0
Mexico	20 016 375
Nicaragua	1 595 366
Panama	64 414
Paraguay	1 999 482
Peru	359 011
Saint Kitts and Nevis	0
Saint Lucia	0
Saint Vincent and the Grenadines	708
Suriname	0
Trinidad and Tobago	0
United States of America	0
Uruguay	0
Venezuela	8 049 594
TOTAL	**57 971 679**

Countries with a zero number did not report any children receiving preventive chemotherapy for soil-transmitted helminthiases to WHO in 2020. However, it may be that some children received deworming medication in a clinical setting.
This table is based on data provided on the Global Health Observatory, WHO website.

ensured that a monitoring and surveillance component was embedded into its school-based deworming program (30). With increasing acceptance, experience and success of deworming programs for children, the case for providing deworming treatment for women of reproductive age became stronger (31, 32). In the Americas, it was estimated that over 47 000 000 women of reproductive age, including over 500 000 pregnant women, were in need of PC for STH (33). Because of the concern about deworming during pregnancy, a systematic review of the effects of exposure to albendazole and mebendazole during pregnancy was undertaken. This review established that there was no additional adverse risk related to deworming, to either the mother or the baby, even when the deworming treatment was inadvertently administered during the first trimester (34). To assist program managers in implementing deworming programs for women of reproductive age, a screening tool to rule out women who were likely to be in their first trimester was developed so that these women could be identified and treatment offered to them at a later time (35).

COLLABORATIONS WITH OTHER ORGANIZATIONS

One of the important aspects of being a PAHO/WHO Collaborating Centre is the opportunity of interacting with other Collaborating Centres within the PAHO network and around the world so that relevant activities and lessons learned can be shared. In 2021, PAHO invited Collaborating Centres in the region to participate in a live poster webinar describing their contributions to the SDGs (36). Globally, there are seven Collaborating Centres with an STH focus. These CCs have recently formed a network to advance mutual goals. Other collaborations also offer meaningful exchanges. The PAHO/WHO CC for Research and Training on Parasite Epidemiology and Control is an international co-applicant on a 5-year European-based Centre of Excellence for NTD with the aim of sharing technical expertise in parasite epidemiology (2021-2026). It is also a founding member of the Canadian Network for Neglected Tropical Diseases, where contributions made by Canadian researchers in the field of NTD research have been highlighted, even though many of these diseases are not endemic to Canada (37). Further guidance has been provided to organizations which include deworming in its programming (e.g., for adolescent girls and women of reproductive age) and contribute to policy and practice review through participation in the STH Advisory Committee of the STH Coalition, supported by Children Without Worms (38,39). As part of the global campaign to reduce the disease burden caused by STHs, knowledge dissemination is important, and access to continuing support, essential (40,41).

CONCLUSIONS

The PAHO/WHO Collaborating Centre for Research and Training in Parasite Epidemiology and Control actively contributes to the goals of the NTD Road Map 2021-2030 and achievement of the SDGs. Increasing activities with a variety of partners, both in the Americas and globally, is evidence of robust knowledge exchange among people dedicated to eliminating the disease burden caused by STHs and NTDs by 2030.

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Eliminar la morbilidad causada por las enfermedades tropicales desatendidas para el 2030

RESUMEN El objetivo de este artículo es proporcionar ejemplos seleccionados de la labor del centro colaborador de investigación y capacitación en epidemiología y control de parásitos de la Organización Panamericana de la Salud/Organización Mundial de la Salud (OPS/OMS), que contribuye al objetivo de la OMS de eliminar las enfermedades tropicales desatendidas para el 2030. Este centro colaborador de la OPS/OMS alinea sus actividades específicamente con los Objetivos de Desarrollo Sostenible y con los objetivos descritos en la *Hoja de ruta sobre enfermedades tropicales desatendidas 2021-2030* de la OMS. Su función es contribuir al avance de las medidas mundiales sobre las enfermedades tropicales desatendidas, principalmente mediante la elaboración de políticas y la traducción de conocimiento. Recientemente se han completado tres proyectos importantes: 1) finalización del marco de seguimiento y evaluación de la Hoja de ruta sobre enfermedades tropicales desatendidas (publicado en mayo del 2021; este centro colaborador de la OPS/OMS formó parte del grupo de trabajo); 2) elaboración de nuevas directrices para la quimioterapia preventiva de la teniasis por *Taenia solium* (publicado en septiembre del 2021; este centro colaborador fue copresidente); y 3) formulación de un informe de políticas sobre la desparasitación de las adolescentes y las mujeres en edad reproductiva (publicado en enero del 2022; este centro colaborador fue coautor). Estos proyectos son el resultado de la integración del conocimiento y la experiencia de múltiples asociados, como la OPS y la OMS (ambas organizaciones ofrecieron un liderazgo clave), este centro colaborador de la OPS/OMS, así como varios ministerios gubernamentales, organizaciones de la sociedad civil y universidades, entre otros. En conclusión, este centro colaborador de la OPS/OMS ofrece orientaciones oportunas para las políticas de salud pública basadas en la evidencia lideradas por los países, la ejecución de programas costo-efectivos y la determinación de los temas de investigación prioritarios, todo ello destinado, en última instancia, a eliminar la morbilidad atribuible a las enfermedades tropicales desatendidas para el 2030.

Palabras claves Enfermedades parasitarias; sistema de vigilancia sanitaria; mujeres; pobreza; niño.

Eliminação até 2030 da morbidade causada pelas doenças tropicais negligenciadas

RESUMO O objetivo deste manuscrito é fornecer exemplos seletivos do trabalho do Centro Colaborador de Pesquisa e Treinamento em Epidemiologia e Controle de Parasitos da Organização Pan-Americana da Saúde/Organização Mundial da Saúde (OPAS/OMS) que contribuem para a meta da OMS de eliminar até 2030 as doenças tropicais negligenciadas. Este CC da OPAS/OMS alinha especificamente suas atividades com os Objetivos de Desenvolvimento Sustentável e com as metas delineadas no Roteiro da OMS para Doenças Tropicais Negligenciadas 2021-2030. Seu papel é contribuir para o avanço da ação global contra doenças tropicais negligenciadas, principalmente por meio do desenvolvimento de políticas e da tradução de conhecimentos. Três importantes projetos foram concluídos recentemente: 1. Finalização da Estrutura de Monitoramento e Avaliação do Roteiro para as DTN (publicada em maio de 2021 – este CC da OPAS/OMS foi membro do grupo de trabalho); 2. Desenvolvimento de novas diretrizes para a quimioprofilaxia da teníase por *Taenia solium* (publicado em setembro de 2021 – este CC da OPAS/OMS foi copresidente); e 3. Formulação de orientação para políticas de desparasitação para adolescentes e mulheres em idade reprodutiva (publicado em janeiro de 2022 – este CC da OPAS/OMS foi cogestor). Esses projetos são o resultado da integração de conhecimentos e experiência de múltiplos parceiros, incluindo a OPAS e a OMS (onde ambas as organizações forneceram liderança essencial), este CC da OPAS/OMS, ministérios governamentais, organizações da sociedade civil e universidades, entre outros. Em suma, este CC da OPAS/OMS contribui com orientações oportunas para uma política de saúde pública liderada pelos países e informada com base em evidências, para a implementação de programas com boa relação custo-benefício e para a identificação de tópicos prioritários de pesquisa – todos focados, em última análise, na eliminação da morbidade atribuível às DTN até 2030.

Palavras-chave Doenças parasitárias; sistema de vigilância sanitária; mulheres; pobreza; criança.