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Particulate air pollution in Tashkent and consequences to population health

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ABSTRACT

Introduction. Air pollution, and particularly high concentrations of $PM_{2.5}$ can have severe consequences to human health. Particulate air pollution raises the risks for various diseases, including chronic obstructive pulmonary disease, ischemic heart disease, stroke, lung cancer, and diabetes type 2. For all of Uzbekistan, over 2021 the expected value of mortality attributable to Ambient $PM_{2.5}$ pollution was 27,099. This is a significant cause of the mortality in the country. Top five sources contributing to outdoor $PM_{2.5}$ concentration were: residential, industry, energy, anthropogenic dust, and agriculture.

Materials and methods. To estimate $PM_{2.5}$ attributable mortality in Tashkent, we downloaded the available $PM_{2.5}$ from the air quality monitor at the US Embassy in Tashkent, and the satellite-based $PM_{2.5}$ concentration data for the city of Tashkent from the Atmospheric Composition Analysis Group at the Washington University in St. Louis. Population data for Tashkent city was taken from the official statistics agency of Uzbekistan. We then applied a $PM_{2.5}$ attributable mortality model.

Results. For the years 2019 to 2022 we estimate a range of mortality in the city from a low of 3095 to a high of 4736; using the same attributable mortality model but the different sources of $PM_{2.5}$ concentrations.

Limitations. The monitor at the US Embassy may not represent average particulate matter concentrations across the entire city. Satellite data do not directly measure $PM_{2.5}$ concentrations and in general rely on ground monitors for verification. Tashkent is growing very quickly and the official estimates of the city's population may be on the low side.

Conclusion. Air quality in Tashkent is a serious health issue and a source of annual mortality. Tashkent needs a detailed emission inventory and source apportionment to support a high quality and feasible air quality management plan and to address the high costs of air pollution.

Keywords: air pollution; $PM_{2.5}$; attributable mortality; pollution sources

Compliance with ethical standards. The study does not require the submission of the conclusion of the biomedical ethics committee or other documents.

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Загрязнение воздуха частицами в Ташкенте и последствия для здоровья населения

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РЕЗЮМЕ

Введение. Загрязнение воздуха, и особенно высокие концентрации $PM_{2.5}$, могут иметь серьёзные последствия для здоровья человека. Загрязнение воздуха твёрдыми частицами повышает риск развития различных заболеваний, включая хроническую обструктивную болезнь лёгких, ишемическую болезнь сердца, инсульт, рак лёгких и диабет II типа. Для всего Узбекистана в 2021 г. ожидаемое значение смертности, связанной с загрязнением окружающей среды $PM_{2.5}$, составило 27 099. Это значимая причина смертности в стране. Пять основных источников, способствующих накоплению $PM_{2.5}$ в атмосферном воздухе, включают жилые здания, промышленность, энергетику, антропогенную пыль и сельское хозяйство.

Материалы и методы. Для оценки смертности, связанной с $PM_{2.5}$ в Ташкенте, мы загрузили имеющиеся данные о содержании $PM_{2.5}$ из монитора качества воздуха Посольства США в Ташкенте и спутниковые данные о концентрации $PM_{2.5}$ для города Ташкента, полученные из Группы анализа состава атмосферы Вашингтонского университета в Сент-Луисе. Данные о населении города Ташкента взяты из официального статистического агентства Узбекистана. Затем мы применили модель расчёта смертности, обусловленной $PM_{2.5}$.

Результаты. За период с 2019 по 2022 г. мы оцениваем диапазон смертности в городе от минимума в 3095 до максимума в 4736; используя одинаковую модель смертности, обусловленную $PM_{2.5}$, но разные источники концентрации $PM_{2.5}$.

Ограничения исследования. Монитор в посольстве США может не отображать средние концентрации твёрдых частиц по всему городу. Спутниковые данные не измеряют концентрации $PM_{2.5}$ напрямую и полагаются на наземные мониторы для проверки. Ташкент растёт очень быстро, и официальные оценки численности населения города могут быть заниженными.

Заключение. Качество воздуха в Ташкенте является серьёзной проблемой для здоровья и источником ежегодной смертности. Ташкенту необходим подробный кадастр выбросов и распределения источников для поддержки высококачественного и осуществимого плана управления качеством воздуха и решения проблемы высоких затрат на снижение загрязнения воздуха.

Ключевые слова: загрязнение воздуха; $PM_{2.5}$; атрибутивная смертность; источники загрязнения

Соблюдение этических стандартов. Исследование не требует представления заключения комитета по биомедицинской этике или иных документов.

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Участие авторов: Броди М.С. — общая идея и дизайн исследования, основной автор текста; Илесалиев Д.И. — сбор литературных и популяционных данных; Саидов Д.Н. — сбор данных о концентрации твёрдых частиц и обработка данных; Разиков Р.С. — предоставление помещений и согласование. Все соавторы — утверждение окончательного варианта статьи, ответственность за целостность всех частей статьи.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов в связи с публикацией данной статьи.

Финансирование. Работа выполнена по Программе специалистов Fulbright в США с предоставлением доктору Майклу Броди гранта с финансированием его пребывания в Ташкентском государственном транспортном университете. Ташкентский государственный транспортный университет принял доктора Броди, предоставил жильё и возможности для этой работы. Доктор Владимир Поташников помогал с моделированием атрибутивной смертности. Исследование не имело дополнительного финансирования.

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Introduction

Air pollution, and particularly high concentrations of PM_{2.5} can have severe consequences to human health. Particulate air pollution raises the risks of various diseases, including chronic obstructive pulmonary disease, ischemic heart disease, stroke, lung cancer and type 2 diabetes. From the Global Burden of Diseases [1] ambient air pollution in 2021 has been estimated to have caused about 4.72 million premature deaths worldwide.

For all of Uzbekistan, in 2021 the expected value of mortality attributable to ambient PM_{2.5} pollution was 27,099. PM_{2.5} attributable mortality for all of Uzbekistan for the period from 1990 to 2021, with upper and lower bounds is shown below in Figure 1 [1].

This is a significant cause of mortality in the country, and air pollution was one of the top 10 risk factors [2]. And the figure shows only mortality, not any morbidity.

According to the State of Global Air [3] the top five sources contributing to outdoor PM_{2.5} concentration were: residential — 8.9%; industry — 6.9%; energy — 12.1%; anthropogenic dust — 3.6%; and agriculture — 3.4%. According to McDuffie et al. [4]

contributions to total outdoor PM_{2.5} exposure for Uzbekistan were: from total coal combustion — 8.7%, from oil and gas combustion — 9.9% and from biofuels — 9.8%. For the city of Tashkent, the equivalent numbers were from total coal combustion — 11.7%, from oil and gas — 10.3% and from biofuels 7.1% of the total exposure to ambient PM_{2.5}. A proxy for particulate emissions, GHG emissions for all of Uzbekistan in 2010 [5], is shown in Table 1.

According to the World Bank [6] source contributions to annual average PM_{2.5} concentrations were residential and commercial heating 29%, waste burning 1%, urban dust 6%, heavy industry 6%, light industry 7%, windblown dust 36%, and transport 16%.

Materials and Methods

To assess the situation specifically in Tashkent city we downloaded all of the available PM_{2.5} data available from the air quality monitor at the US Embassy in Tashkent [7]. We also downloaded PM_{2.5} concentration data for the city of Tashkent from the Atmospheric Composition Analysis Group at the Washington University in St. Louis [8]. These are estimates of ground-level PM_{2.5} using Aerosol Optical Depth (AOD) retrievals

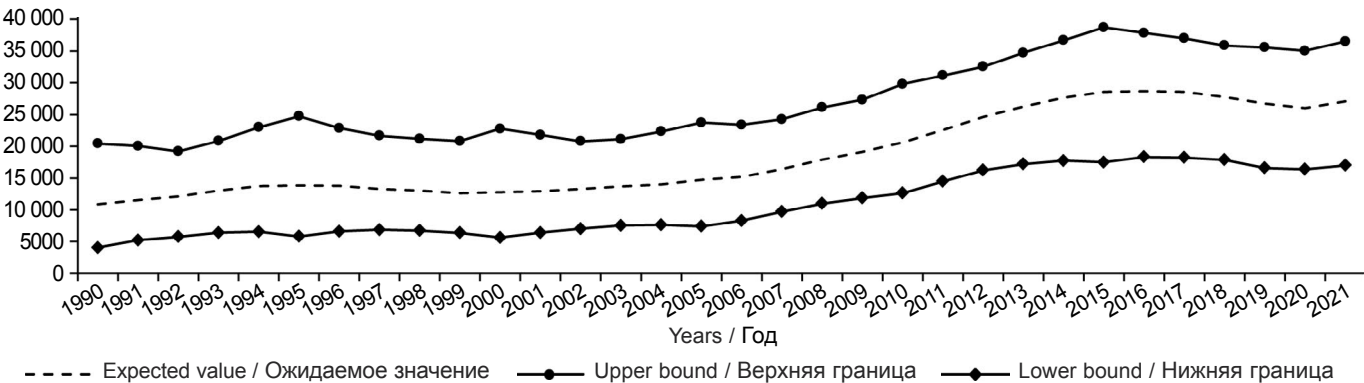


Fig. 1. Annual Mortality from Ambient PM_{2.5} Air Pollution in Uzbekistan 1990–2021.
Рис. 1. Ежегодная атрибутивная смертность от загрязнения атмосферного воздуха частиц PM_{2.5} в Узбекистане, 1990–2021 гг.

Direct GHG emissions by categories in 2010, Gg CO₂-eq
Прямые выбросы парниковых газов по категориям в 2010 г., Гг CO₂-экв.

Table 1 / Таблица 1

Category / Категория	n
Energy Industries / Энергетическая промышленность	31 550
Manufacturing Industries and Construction / Производство и строительство	7520
Transport / Транспорт	12 745
Commercial/Institutional / Коммерческие/Институциональные	10 453
Residential / Жилой сектор	31 918
Agriculture / Сельское хозяйство	1386
Other / Другое	132

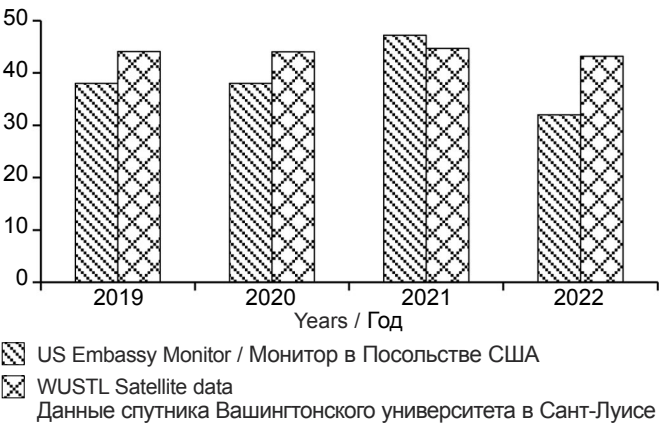


Fig. 2. PM_{2.5} concentration in Tashkent City.
Рис. 2. Концентрация PM_{2.5} в городе Ташкенте.

from the NASA MODIS, MISR, and SeaWIFS instruments [9]. Each of these two sources gave somewhat different estimates of annual particulate pollution concentrations. There is not a simple explanation. However, the ground level monitor is a single point source for a large area. And the satellite coverage is a broader geographic coverage, but not a direct measurement of the particulates themselves. In 2022 there were some missing data for four months of the year, however the data were between the readings for the same months for the previous and the following year. Both of the series of annual concentrations are shown in Figure 2.

Population data for Tashkent city were taken from the official statistics agency of Uzbekistan (UzStat [10, 11]). Official population data for 2023 were not yet available at the time of this analysis. Background mortality rates were from UzStat [12] and Komolova et al. [13] and background rates of non-communicable diseases were from the World Health Organization [14].

Results

We applied a PM_{2.5} attributable mortality model based on [15]; which in turn was adapted from the particulate matter risk curves from the Global Burden of Diseases [16].

Discussion

Air pollution is one of the most serious risk factors for non-communicable diseases and is critical for the protection of public health (WHO [17]). Sources of outdoor air pollution, as discussed above, require action by local, national and regional level policy-makers working in sectors like energy, manufacturing, transport, commercial, residential and agricultural sectors.

In the past and in other countries the use of pollution control and clean technologies have reduced industrial and energy

Table 2 / Таблица 2
Mortality attributable to PM_{2.5} pollution in Tashkent City
Смертность от загрязнения PM_{2.5} в городе Ташкенте

Index Показатель	Year / Год			
	2019	2020	2021	2021
Population / Население	2,510,000	2,572,000	2,694,000	2,862,000
PM _{2.5} concentration US Embassy monitor Концентрация PM _{2.5} Монитор в посольстве США	38	38	47.2	32
Attributable Mortality ~ Атрибутивная смертность ~	3226	4336	4333	3095
PM _{2.5} concentration WUSTL satellite data Концентрация PM _{2.5} Данные спутника ВУСЛ	44.1	44.0	44.7	43.2
Attributable Mortality Атрибутивная смертность	3528	4736	4197	3712

smokestack emissions. Automobile technologies, cleaner fuels, including cleaner heavy-duty diesel vehicle low-sulfur fuels. Newer electric vehicles are another proven approach to reducing harmful emissions. Increasing rapid urban transit and walking and cycling networks in cities should also be priorities.

Improved management of urban and agricultural waste, particularly the capture of methane gas emitted from waste sites for use as biogas, should be a greater priority. Additionally, improving the energy efficiency of buildings, use of the most efficient household heating and lighting will also be a key part of an emission reduction strategy. In a country with such abundant solar radiation as Uzbekistan, development of solar powered electricity, at the industrial and the rooftop residential/commercial level should be occurring as quickly as feasible.

Conclusion

Air quality in Tashkent is a serious health issue and a source of annual mortality. There may be some uncertainty about the precise estimates with two sets of data, but the basic conclusions don't change. On any day, one can go to various websites to see the real-time PM concentrations or the Air Quality Index, virtually anywhere in the world. These include sites such as the World Air Quality Index (waqi.info), IQAir (iqair.com), Purple Air (<https://map.purpleair.com/>) in addition to the US AirNow site used in this analysis. Finally, Tashkent needs a detailed emission inventory and source apportionment to support a high quality and feasible air quality management plan and to address the high costs of air pollution [6, 18].

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