

**ANALYSIS OF ACCIDENTAL TRANSMISSION IMPACTS IN THE CHAIN «WASTE MANAGEMENT SYSTEM – PUBLIC HEALTH»****Yevheniia Ziabina**,  ORCID: <https://orcid.org/0000-0003-0832-7932>

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**Abstract:** *The article summarises arguments and counter-arguments within the scientific debate on the generated waste impact on public health. The main goal of the conducted research is analysis of accidental transmission effects in the chain «waste management system – public health». The systematisation of sources and approaches to solving the problem of waste management system for the population health proved that over 900 publications on the researched topic were cited by in the Web of Science database. At the same time, there are the TOP-5 leading countries in which the problem of the generated waste impact on public health is actively studied: the USA (198 publications), India (107 publications), China (103 publications), England (86 publications), Italy (49 publications). The urgency of solving this scientific problem lies in the fact that in the process of urbanisation and constant industry development, the world waste level is increasing. It provokes a negative impact on the population health. In the article, the analysis of accidental transmission effects in the chain «waste management system – public health» is carried out in the following logical sequence: bibliometric analysis of publications on the researched topic; multiple correlation-regression analysis; check of the built model adequacy using the average approximation error. The conducted research tools were: VOSviewer (an application for producing and visualising bibliometric networks) and MS Excel. The study period was 2000-2019 before the COVID-19 pandemic. Dynamic indicators of the waste volume and disposal, number of the first-time registered disease cases in Ukraine were chosen as the study object. These indicators provide an opportunity to describe significance of the waste management system impact on the population morbidity level. The article presents results of the multiple correlation-regression analysis. It confirmed that with an increase in the waste volume by 1%, the number of the first-time registered disease cases will rise by 0.73%. The study empirically confirms the constructed model adequacy regarding influence of the generated and disposed waste volume and the population health level. The research results can be useful for further scientific activity on this topic.*

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**Introduction.** According to expert estimates (sbd.sm.gov.ua, 2019), the total area of landfills in Ukraine occupies 4-7% of the country's territory. Some of them have long been overcrowded or do not meet environmental safety standards. The situation is constantly worsening: every year landfills are reinforced by approximately 15-17 million tons. Besides, the situation is complicated by the huge number of illegal landfills (more than 32,000 throughout the country).

According to data (Bondarenko, 2022), only 4% of waste is processed in Ukraine while in European countries – at least 40%. In Sweden, 99% of garbage is used as fuel or raw material (Yermolenko, 2022). Also, their population has a fairly high level of health, one of the best in the world.

Ukraine also lacks for technologies and capacities to process dangerous waste. Therefore, thousands of waste tons are slowly poisoning the environment and the population health (Bondarenko, 2022).

There are many publications on waste management problems in Ukraine, the experience of other countries in solving these issues. Meanwhile, mutual influence of waste management system and public health has not been sufficiently studied.

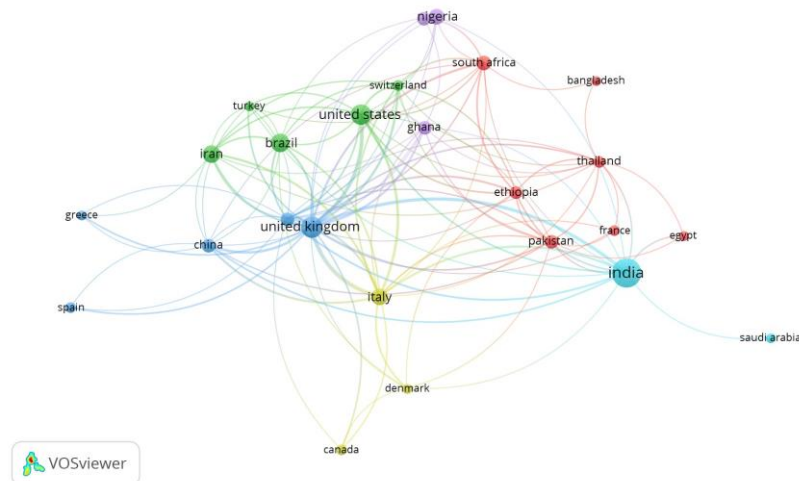
Thus, there is a need to analyse components in the chain «waste management system – public health». After all, the successfully built waste management system is a foundation for building a circular economy based on recovery and rational consumption of resources. Today, that is a part of the EU Green Course.

The research purpose is analysis of accidental transmission impacts in the chain «waste management system – public health».

**Literature Review.** According to the Web of Science database, 943 publications (articles and proceeding papers) published during 1991-2022 in English are devoted to the waste management system and public health. At the same time, only 413 publications are publicly available. Half of all works were printed during 2018-2022, which indicates the relevance of this topic.

Most research is conducted in the fields of Environmental Sciences Ecology, Engineering, Science Technology, Public Environmental Occupational Health, Water Resources, etc. Additionally, there are only 34 publications in Business Economics.

Researchers (Figure 1) studied issues of waste management system and public health. Usually, they belonged to the United States (198 publications), India (107 publications), China (103 publications), England (86 publications), Italy (49 publications), Australia (48 publications), Canada (47 publications) and Brazil (45 publications).



**Figure 1. Bibliometric map of the analysed documents by country**

Sources: developed by the authors with VOSviewer (2023).

At the same time, only three publications by Ukrainian authors were found. Their works are devoted to the management of public health risks in companies working with solid waste processing (Kalashnikova et al., 2021), portable batteries and their disposal (Shuptar-Poryvaieva et al., 2020), medical institution effluents (Khan et al., 2021).

Only four authors have five publications each on the chosen topic: Wilson D.C (England), Ali M. (Japan), Chang N.B. (China), Velis C.A. (England). Their works are focused on waste recycling drivers, solid waste management and its benefits, impact of burning plastic waste on public health, medical and healthcare waste,



water, food safety, consumption, ground water, irrigations, pharmaceuticals, heavy metals, sewage, water pollution, etc. In another cluster (red), researches mainly concern diseases caused by various pollutants.

In recent years, the largest number of publications is devoted to issues of management and sustainable development, life-circle assessment, human health, environmental impacts, biomedical waste, healthcare waste, food waste, incineration, recovery, recycling.

Although only three publications by Ukrainian authors were included in the selection, many Ukrainian researchers are investigating waste management and public health. The works deal with solid domestic waste at the heating enterprises (Panchenko et al., 2021), air pollution, health and economic growth (Smiiianov et al., 2020), net zero (Pimonenko et al., 2017), ecosystem (Navickas et al., 2021), influence of waste incineration and obtaining energy from it to the public health (Matvieieva et al., 2023).

Waste management is closely related to energy-efficient consumption (Chygryn et al., 2022; Vasyliieva et al., 2019), smart grids (Lyulyov et al., 2021), renewable energy system (Kolosok et al., 2021; Rosokhata et al., 2021), energy and economic security (Samusevych et al., 2021).

There are also works devoted to various aspects public health (Vasyliieva et al., 2020; Smiiianov et al., 2020; Letunovska et al., 2021), resilient healthcare organisation (Chygryn and Khomenko, 2023), population health (Kuzior et al., 2022), social sector (Lyeonov et al., 2021).

Simultaneously, the relationship between a poorly developed waste management system and the population health remains unexplored.

The study will analyse the accidental transmission impacts in the chain «waste management system – public health».

**Methodology and research methods.** To write the literature review, 943 publications (articles and proceeding papers) published during 1991-2022 in English were found in the Web of Science database. They concerned waste management and public health.

The following methods were used: statistical – collection and analysis of statistical data on waste management and healthcare.

The multiple correlation-regression analysis is used to check the relationship between generated waste, its disposal and the population morbidity rate.

The multiple correlation-regression analysis was applied according to the formula:

$$y_i = \alpha_0 + \alpha_1 w_i + \alpha_2 w_i^2 + \alpha_3 w_i^3 + \dots + \alpha_n w_i^n + \varepsilon \quad (i = 1, 2, 3 \dots, n) \quad (1)$$

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \dots \\ y_n \end{bmatrix} = \begin{bmatrix} 1 & w_1 & w_1^2 & \dots & w_1^m \\ 1 & w_2 & w_2^2 & \dots & w_2^m \\ 1 & w_3 & w_3^2 & \dots & w_3^m \\ \dots & \dots & \dots & \dots & \dots \\ 1 & w_n & w_n^2 & \dots & w_n^m \end{bmatrix} \begin{bmatrix} \alpha_0 \\ \alpha_1 \\ \alpha_2 \\ \dots \\ \alpha_m \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \dots \\ \varepsilon_n \end{bmatrix} \quad (2)$$

The correlation coefficient was calculated according to the formula:

$$r = \frac{\sum_{i=1}^n (w_i - \bar{w})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^n (w_i - \bar{w})^2 \cdot \sum_{i=1}^n (Y_i - \bar{Y})^2}} \quad (3)$$

The Pearson correlation criteria were used to measure the linear relationship degree (Table 1) between indicators (Table 2).

**Table 1. The Pearson correlation criteria**

Type of link	Permissible limits
Strong direct link	From 1 to 0.7
Strong inverse link	From -1 to -0.7
Average direct link	From 0.699 to 0.3
Average inverse link	From -0.699 to -0.3
Weak direct link	From 0.299 to 0
Weak inverse link	From -0.299 to 0

Sources: developed by the authors.

To conduct the correlation-regression analysis, the following indicators were involved: the number of newly registered disease cases, generated waste, utilised waste.

**Table 2. Description of the source data**

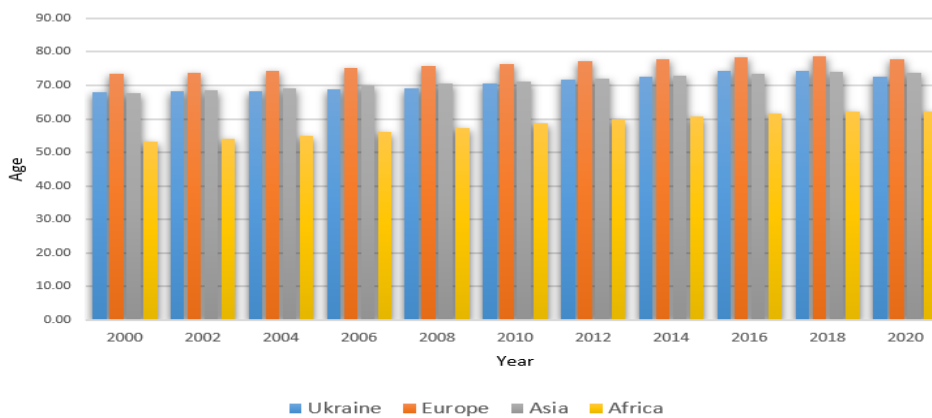
Indicator	Abbreviation	Measurement units	Resource
The number of newly registered disease cases	ND	Thousands of cases	Ukrastat
Generated waste	WG	Thousands of tons	World Bank
Utilised waste	WU	Thousands of tons	World Bank

Sources: developed by the authors.

The investigation hypothesis: there is a direct relationship between disease and generated waste; an inverse relationship between disease and utilised waste.

**Results.** Problems related to the negative impact of waste management on the population health began to manifest themselves in the conditions of human urbanisation, population growth and waste increase. The main reasons for the morbidity rate and epidemics increase were pollution of air, soil and water precisely because of improper waste handling and its disposal.

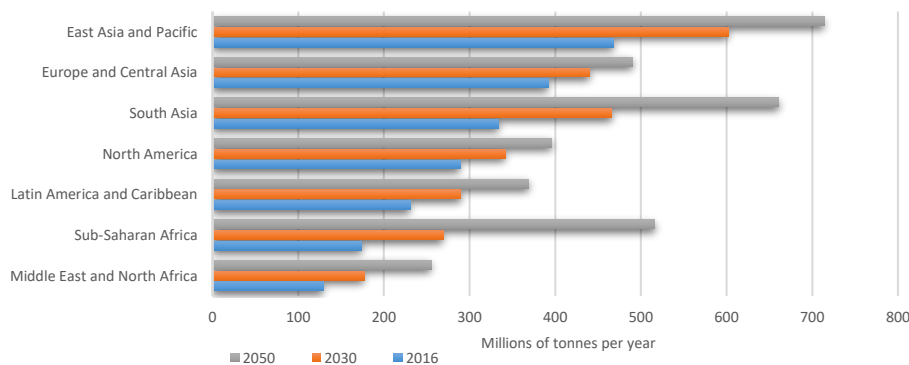
Today, the biggest problems in the chain «waste management system – public health» are faced by developing countries. Ukraine is one of those countries. At the same time, more than 70% of the world’s population lives in such countries. It is worth noting that the average life expectancy in developing countries is very lower than in developed countries (Figure 4).



**Figure 4. Average life expectancy, 2000-2021**

Sources: constructed by the authors based on the World Bank data (2023).

Thus, within achieving the Sustainable Development Goals (United Nations, 2023), representatives of the World Bank (2023) conducted a study on forecasting waste generation in certain parts of the world for 2030 and 2050. It should be noted that the most critical situation is in the regions of East Asia and Pacific, South Asia and Sub-Saharan Africa. Here, the waste generation level by 2050 may hypothetically increase by two or three times compared to 2016 (Figure 5).



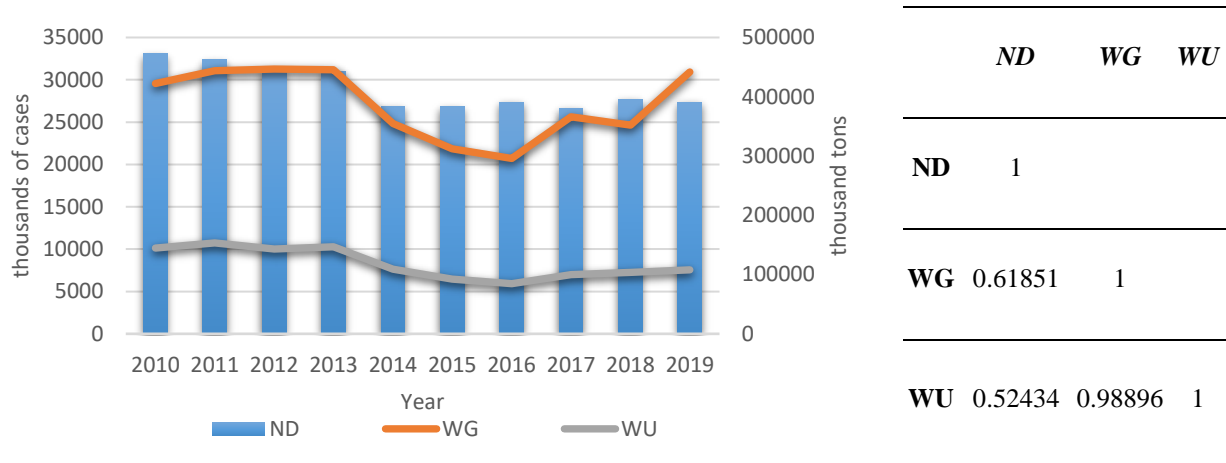
**Figure 5. Expected waste generation by region (million tons/year)**

Sources: constructed by the authors based on the World Bank data (2023).

Today, there is a large number of studies to the given problem. Using different types of analysis and calculations, scientists try to establish the main impact determinants on waste management for reducing the population morbidity rate.

As a study part, it was decided to conduct the regression-correlation analysis of the waste generation and disposal impact on the population health.

The results of the correlation analysis (Figure 6) demonstrate a direct moderate level of connection (0.62) between indicators of the first-time registered disease cases and waste generation. Also, there is a direct moderate level of connection (0.52) between the indicators of the first-time registered disease cases and disposed waste. The calculation includes increase in diseases of the Ukrainian population.



**Figure 6. Results of correlation analysis**

Sources: calculated by the authors

For a more detailed analysis of the relationship between multiple independent variables, multiple regression calculations were performed. The results of the multiple regression analysis are presented in Figure 7.

<i>Regression Statistics</i>	
Multiple R	0.85446302
R Square	0.730107052
Adjusted R Square	0.69835494
Standard Error	1433.550878
Observations	20

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	2	94508343	47254172	22.99397	1.46E-05
Residual	17	34936158	2055068		
Total	19	129444501			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	32465.38826	451.37458	71.9256	1.45E-22	31513.07	33417.71
WG	-0.058831269	0.0109873	-5.35449	5.26E-05	-0.08201	-0.03565
WU	0.165469903	0.0353658	4.678813	0.000216	0.090855	0.240085

**Figure 7. Results of multiple regression analysis**

Sources: calculated by the authors.

Taking into account the calculation results, we can conclude that the multicollinearity index (0.854) indicates a strong direct relationship between the studied variables. At the same time, the coefficient of determination (0.73) and the adjusted coefficient of determination (0.698) indicate that with increase in waste by 1%, newly registered disease cases will rise by 0.73%.

When checking the obtained model quality, the average approximation error was calculated:

$$S = \varepsilon_i y_i = \phi(w_i) y_i \tag{4}$$

$$\varepsilon_i = y'_i(w) - y_i(w) \tag{5}$$

**Table 3. The results of calculating the average approximation error**

<i>Observation</i>	<i>Predicted</i>	<i>ND</i>	<i>Residuals</i>	<i>Approximation error</i>	<i>Observation</i>	<i>Predicted</i>	<i>ND</i>	<i>Residuals</i>	<i>Approximation error</i>
<b>1</b>	32539.37006	931.62994	2.863085	<b>11</b>	31577.30351	1502.6965	4.758787		
<b>2</b>	32695.01971	496.98029	1.520049	<b>12</b>	31734.15682	646.84318	2.038318		
<b>3</b>	32645.17816	-412.17816	1.2626	<b>13</b>	29864.91344	1297.0866	4.343179		
<b>4</b>	32517.97768	67.022322	0.206109	<b>14</b>	30549.96553	474.03447	1.551669		
<b>5</b>	32462.0102	110.9898	0.341907	<b>15</b>	29662.83164	-2781.8316	9.378173		
<b>6</b>	32466.36571	445.63429	1.372603	<b>16</b>	29394.24844	-2605.2484	8.863123		
<b>7</b>	32466.20713	-226.20713	0.696746	<b>17</b>	29062.74224	-1701.7422	5.855408		
<b>8</b>	32483.93022	323.06978	0.994553	<b>18</b>	27486.27304	-871.27304	3.169848		
<b>9</b>	32482.05603	-15.056032	0.046352	<b>19</b>	28889.43343	-1167.9302	4.042759		
<b>10</b>	32529.66974	502.33026	1.544222	<b>20</b>	24365.14947	2983.1495	12.24351		

Sources: calculated by the authors.

The intermediate results of the average approximation error calculation are shown in Table 3. Its value 3.35% shows the constructed model adequacy (permissible limits of the average approximation error are 10-12%).

**Conclusions.** Over the past year, the attention focus of all developed countries has been changed from the goals of transition to a carbon-neutral economy to the political and military situation in Ukraine. It is necessary to understand that stability and security in all countries depends on the victory of Ukraine in the war with the Russian Federation. Therefore, significant funds are allocated to strengthening the country’s defence capabilities. Meanwhile, European countries, the USA, Great Britain and others are actively reloading their own military-industrial complexes. All these factors directly or indirectly affect generated waste, safety and correctness of their disposal (especially, in the temporarily occupied territories of Ukraine). Accordingly, it influences the population morbidity rate.

The bibliometric analysis results indicate a deep research interest in this topic. Many domestic (Kuzior et al., 2022; Matvieieva et al., 2023; Pimonenko et al., 2017) and foreign scientists (Ziraba et al., 2016; Forastiere et al., 2011) investigate the generated waste impact on the population health. Only the Web of Science database cited more than 900 publications on the subject under study. At the same time, it is possible to note the TOP-5 leading countries in which the problem of the generated waste impact on public health is actively studied: the USA (198 publications), India (107 publications), China (103 publications), England (86 publications), Italy (49 publications).

As a part of the multiple correlation-regression analysis, it was proven that with increase in waste by 1%, the first-time registered disease cases can rise by 0.73%. Also, these results are confirmed by checking the built model, by calculating the average approximation error (3.35%). In general, the calculation results and literature review indicate a big problem, which over the years (especially, in countries with a weak economy) can become fatal.

Considering current realities in Ukraine, the Ministry of Environmental Protection and Natural Resources in cooperation with other authorities (the Ministry of Health, the Ministry of Energy, the Ministry of Finance) are developing certain strategies and programs for the further post-war country reconstruction within waste management and its impact on public health.

**Authors’ contributions:** conceptualization, Ye. Z. and L. K.; methodology, Ye. Z. and L. K.; software, Ye. Z., L. K. and E. O.; validation, Ye. Z.; formal analysis, Ye. Z. and E. O.; investigation, Ye. Z.; resources, Ye. Z. and L. K.; data curation, Ye. Z., and E. O.; writing-original draft preparation, Ye. Z. and L. K.; writing-review and editing, L. K.; visualisation, Ye. Z., L. K. and E. O.; supervision, Ye. Z.; project administration, Ye. Z.; funding acquisition, Ye. Z.

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**Informed consent statement:** Not applicable.

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**Дослідження казуальних трансмісійних впливів в ланцюзі «система управління відходами – здоров'я населення»**

Стаття узагальнює аргументи та контраргументи в межах наукової дискусії з питання впливу утворених відходів на здоров'я населення. Основною метою проведеного дослідження є аналіз казуальних трансмісійних впливів в ланцюзі «система управління відходами – здоров'я населення». Систематизація літературних джерел та підходів до вирішення проблеми системи управління відходами на здоров'я населення засвідчила, що тільки наукометричною базою даних Web of Science цитовано більше 900 публікацій за досліджуваною тематикою. При цьому можна відмітити ТОП-5 країн лідерів, в яких активно вивчається проблема впливу утворених відходів на громадське здоров'я: США (198 публікацій), Індія (107 публікацій), Китай (103 публікацій), Англія (86 публікацій), Італія (49 публікацій). Актуальність вирішення даної наукової проблеми полягає в тому, що в процесі урбанізації та постійного розвитку промисловості рівень відходів в світі збільшується, що провокує негативний вплив на здоров'я населення. Дослідження питання аналізу казуальних трансмісійних впливів в ланцюзі «система управління відходами – здоров'я населення» здійснено в такій логічній послідовності: бібліометричний аналіз публікацій за досліджуваною тематикою; множинний кореляційно-регресійний аналіз; перевірка на адекватність побудованої моделі за допомогою середньої похибки апроксимації. Інструментарієм проведеного дослідження стали: VOSviewer (програмний засіб для побудови та візуалізації бібліометричних мереж) та MS Excel, періодом дослідження обрано 2000-2019 роки до пандемії COVID-19. Об'єктом дослідження обрано динамічні показники обсягу та утилізації утворених відходів, кількість уперше зареєстрованих випадків захворювань в Україні. Саме ці показники дають можливість ґрунтовно описати значущість впливу системи управління відходами на рівень захворюваності населення. У статті представлено результати множинного кореляційно-регресійного аналізу, який засвідчив, що при зростанні обсягу відходів на 1% кількість уперше зареєстрованих випадків захворювань збільшиться на 0,73 %. Дослідження емпірично підтверджує адекватність побудованої моделі, щодо впливу обсягу утворених та утилізованих відходів на рівень здоров'я населення. Результати проведеного дослідження можуть бути корисними для подальшої наукової діяльності за даною тематикою.

**Ключові слова:** управління системою відходів, здоров'я населення, циркулярна економіка, сталий розвиток, захворювання.