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Epidemiological study on the incidence of rabies in holy Karbala Governorate: 2020 to 2024

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ABSTRACT

Rabies is a zoonotic disease with a global prevalence, affecting both humans and animals. Due to the importance of the disease, this topic was selected to understand the epidemiology of rabies and its relation to certain demographic characteristics. Data were collected from the years 2020 to 2024 from the (CDD) Communicable Diseases Division in Karbala Governorate. The statistics included (number of cases, age, sex, infection during the months of the year, and residential areas). The results revealed that the total number of rabies cases for both sexes was (2217) with (1247) cases in males by (56.25%) while (970) cases in females by (43.75%). This result shows that the infection rate in females is lower than in males. It was observed that the highest number of infections occurred in the years 2022 and 2023, with (545 and 537) cases, respectively, representing by (24.582%) and (24.221%). The lowest number of infections was recorded in (2024) in number (322) cases, representing by (14.524%). The highest infection rates in age groups were observed in adolescents and young adults (10-14) years and (15-19) years, while the lowest infection rates were seen in very young children (1-4) years and the elderly (≥ 65 years). A clear variation was noted between urban and rural areas, with higher infection rates in rural areas compared to urban areas.

Keywords: Rabies, Zoonotic disease, Epidemiology, Karbala Governorate, Communicable Diseases Division (CDD), Incidence.

Introduction

Rabies is a serious viral disease that affects the central nervous system of humans and animals; is often fatal if not treated promptly (Beard, 2001). The disease is classified as a neglected tropical disease, as it primarily affects poor and vulnerable population groups in remote rural areas. In most cases, it causes death once clinical symptoms appear, unless appropriate preventive measures are taken (Beard, 2001; Cotran et al., 2005). The disease is caused by the rabies virus, which belongs to the Rhabdoviridae family (Cotran et al., 2005; Takayama, 2005). Dogs are responsible for transmitting the rabies virus to humans in approximately (99%) of human rabies cases; Children between the ages of (5) and (14) years are the most common victims of the disease (Hampson et al., 2015). It is transmitted mainly through the saliva of infected animals via bites or scratches (Hampson et al., 2015; Knobel et al., 2005; Chernet and Nejash, 2016), However, wild animals such as bats, foxes, and wolves may also be carriers of the virus (Zinsstag et al., 2009; WHO, 2013). The disease is considered a zoonotic disease; it can infect both domestic and wild animals, including cats, cattle, sheep, horses, and foxes (Takayama, 2005; Hampson et al., 2015). Stray dogs are the primary reservoir of the virus in many countries, especially in rural areas (Takayama, 2005; Hampson et al., 2015). The rabies virus is transmitted to the brain via the peripheral nerves (WHO, 2018). The incubation period of the

disease usually lasts several months, depending on the distance between the site of infection and the central nervous system (Kuzmina et al., 2013). Symptoms begin to appear when the virus reaches the nervous system and include headache, fever, severe pain, agitation, hydrophobia, and depression. In advanced stages, the patient experiences bouts of agitation and lethargy, followed by respiratory failure, which can lead to death (Beard, 2001; Zinsstag et al., 2009; Mustafa et al., 2015; Srinivasan et al., 2005). Rabies causes approximately (55,000) deaths worldwide annually; (95%) of which occur in Asia and (97%) in Africa; are caused by dog bites (Zhang et al., 2005; Paweska et al., 2006). Meanwhile, some countries, such as the United States, Australia, and Japan, have successfully controlled the disease through animal vaccination programs and veterinary surveillance (Rosatte et al., 2007; Rotivel, 2012; Nadin-Davis et al., 2006). This research is of great importance given that rabies is a fatal viral disease that impacts public health, especially in areas where stray animals are prevalent and health awareness is weak. The holy Karbala Governorate is a region that witnesses a large influx of pilgrims, which increases the likelihood of the spread of infectious diseases.

The study aims to analyze the epidemiological pattern of rabies cases in Karbala Governorate during the period (2020–2024), helping to determine the prevalence of the disease and its associated factors. The results of this study also contribute to supporting prevention efforts, improving monitoring mechanisms, and enhancing vaccination campaigns, thus guiding decision-makers towards developing effective health strategies to limit the spread of the disease.

Materials and Methods

The study was designed based on collecting statistical data from the Ministry of Health/Communicable Diseases Division in Karbala Governorate (CDD). This was achieved by opening disease records and collecting information on rabies for the period from (2020 to 2024). The study included the total number of rabies cases according to age, gender, months of the year, and residential areas. The infected cases were divided into seven groups based on age categories obtained from (CDD) for both sexes. We used Excel to enter statistics and extract the research results, as shown in the tables attached to the results and discussion.

Results and Discussion

The results of our study for the years (2020-2024), as shown in Table (1) and Figure (1), showed that the total number of cases of rabies infection for both sexes amounted to (2217), including (1247) cases of infection for males, at a rate of (56.25%), and (970) cases of infection for females, at a rate of (43.75%), so the infection in females is less than it is in males. There are several factors that explain the higher infection rate among males compared to females. From our perspective, and based on the geographical area we studied, the most prominent of these are: Increased exposure to stray and infected animals; Males, especially in rural areas or communities that rely on animal husbandry, are usually more likely to come into direct contact with animals, whether through farm work, hunting, or herding, which increases their likelihood of being bitten or scratched by infected animals (Kuzmina et al., 2013; Lucas et al., 2008). Also, gender-related behaviors and risks: Males, especially children and adolescents, may be more prone to risk-taking behaviors, such as playing with, approaching, or attempting to handle stray animals without caution, which exposes them to the risk of infection. Also, professional nature: Some professions that require direct contact with animals, such as veterinary workers, hunters, and livestock breeders, are more male-dominated than female-dominated, which increases their exposure to the virus. This is consistent with (Finke and Conzelmann, 2005; Adamson, 1977; Reece and Chawla, 2006).

Table (1): Total number and percentage of rabies-infected individuals of both sexes during the period from 2020 - 2024

Gender	Number of infected cases	Percentage %
Male	1247	56.25
Female	970	43.75
Total	2217	%100

Table (1) shows the total number of rabies cases among both genders during the years (2020 to 2024). It demonstrates that the number of infections among males is higher than among females, reaching nearly double the number of cases among females.

Figure (1) illustrates the total number of rabies cases during the years (2020–2024), showing that the infection rate among males is twice the infection rate among females. As for the results of Table (2), they show the total number and rates of infection with the disease for both sexes for the years (2020-2024).

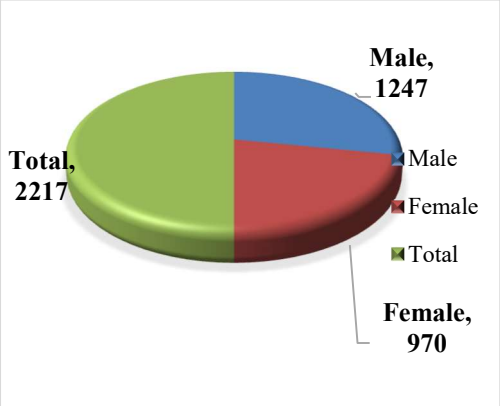

Figure (1): Total number and percentage of rabies-infected individuals of both sexes during the period from 2020 - 2024

We noticed that the highest number of infections was in the years (2022 & 2023) with a number and percentage respectively (545, 537) by (24.582%, 24.221%). As for the lowest number of infections, it was in the year (2024) with a number (322) by (14.524%). When analyzing these percentages and data for table No. (2) and each of tables (3, 4, 5, 6, 7), we can explain the distribution between males and females across the years through the following factors:

1. The persistent disparity in infection rates between males and females: In all years, the infection rate of males was higher than that of females, with the total infection rate among males reaching (56.25%) compared to (43.75%) for females. This confirms the common pattern that males are more susceptible to rabies infection compared to females, which is in line with epidemiological studies in other regions and agrees with (McElhinney et al., 2008; Denduangboripant et al., 2005; WHO, 2011).
2. Difference in the pattern of exposure to the virus: The highest infection percentage in males was (15.11%) with a number of (335) in the year (2022), this year also witnessed the highest total infection rate with (545) cases, by (24.582%), while the lowest infection rate for males, which coincided with the total infection rate, was in the year (2024) with a number of (216) by (9.74%), the total number of infections for this year was (322) by (14.524%), which indicates the possibility of improved preventive measures or a decline in the spread of the disease for females, consistent with (Adamson, 1977; Smith et al., 2019; Kumar et al., 2020), the highest infection rate in the year (2023) was among females with a number of (278) by(12.54%), which may indicate changes in exposure behaviors or an increase in reporting of cases (Adamson, 1977).
3. Shifts in the total number of cases and their impact on distribution: We note that the total number of infections was high in 2022 and 2023, indicating that those years witnessed favorable conditions for the spread of rabies (such as an increase in the number of infected animals or a decline in control measures). In contrast, 2024 witnessed a sharp decline in the number of cases, which may indicate improved prevention strategies or more effective vaccination campaigns (Rotivel, 2012; McElhinney et al., 2008; WHO, 2014).
4. Gender-related behaviors: Males may be more likely to handle animals or be bitten than females, especially in years with a general increase in infections (2022 and 2023). We notice a convergence between infection rates in both sexes, which may indicate changes in female behavior or an increase in reporting of cases compared to previous years (Kuzmina et al., 2013; Adamson, 1977; WHO, 2011).
5. Possible environmental and health factors: Seasonal or environmental factors may have influenced the spread of the disease during some years, leading to increased or decreased incidence in both sexes. Variations in health programs, awareness campaigns, and vaccinations during this period may have played a role in explaining these annual differences (Kuzmina et al., 2013; WHO, 2023); Based on these data, we conclude that males were more susceptible to rabies in most years due to their behavior, occupational environment, and increased exposure to infected animals. However, we note fluctuations in incidence rates among females over the years, which may indicate changes in exposure patterns or case reporting. (Kuzmina et al., 2013; Adamson, 1977; WHO, 2011; WHO, 2023; NASPHV, 2007).

When comparing the analysis of the results according to age groups for the highest and lowest infection rate for the period (2020-2024); we discuss tables (5 and 7) which show the infection according to age groups, where the highest number of infections was (545) during the year (2022) and the lowest number of infections was (322) in the year (2024).

To discuss Table (5) for the year 2022, which represents the highest infection rate, the overall data analysis indicates that the infection rate among males is significantly higher than among females.

Table (2): Total number of rabies cases and the percentage by gender during the period from (2020 - 2024)

Years	Number of Male	Percentage%	Number of Female	Percentage%	Total number	Percentage%
2020	181	8.16	204	9.20	385	17.365
2021	256	11.55	172	7.76	428	19.308
2022	335	15.11	210	9.47	545	24.582
2023	259	11.69	278	12.54	537	24.221
2024	216	9.74	106	4.78	322	14.524
Total	1247	56.25	970	43.75	2217	100%

This calls for an analysis of the factors associated with this trend. Analyzing the results by age group and gender, we found that the infection rate among males was higher than among females across all age groups. The highest infection rate among males was recorded in the (15–19) age group, reaching by (18.72%), which reflects increased exposure of this group to outdoor activities. On the other hand, females recorded the highest infection rate in the (10–14) age group, by (9.91%); however, the overall rate remains lower compared to males in the same age group. The reasons for the higher infection rate among males compared to females include increased participation in outdoor activities among males, such as hunting, playing in open areas, and taking care of animals, as well as differences in behavioral habits. Males are likely to be more daring when dealing with animals and may have lower health awareness or weaker adherence to preventive measures compared to females.

When comparing these results with previous studies, a study published in the Journal of Infectious Diseases showed that the rate of rabies infection among males exceeds that of females in most developing countries due to increased exposure to stray dogs and outdoor activities. Another study conducted in India (2020) found that the (15–19) age group is the most vulnerable to rabies infection due to increased interaction with animals at this stage of life (Smith et al. ,2019 ; Kumar et al. ,2020; WHO ,2014). According to the World Health Organization (WHO), more than (60%) of rabies cases worldwide are reported among males, with a focus on the (10 -19) age groups. Thus, these findings align with global trends in rabies infection rates (WHO, 2014; WHO, 2023; NASPHV, 2007).

As for the analysis of the data in Table (7), which represents the lowest number of infection rates, the table shows that the total number of recorded rabies infections reached (322) cases, among which (216) cases, by (67.08%) for males, which is a much higher percentage than females, where infection reached (106) cases, by (32.92%). These results reflect a greater prevalence of infection among males compared to females, which is consistent with the results recorded globally regarding the high rate of rabies infection among males due to various activities and behaviors (Rotivel, 2012; Reece and Chawla, 2006; WHO, 2014; WHO, 2023). We noticed that the age groups of (10-14), (15-19) and (20-44) represent the largest percentage of infections, indicating that social activity and interaction with animals is the main factor behind the infection (Smith et al., 2019; Kumar et al., 2020; WHO, 2014; WHO, 2023). The age group (20-44) years represents (32.61%) of cases, which reflects the nature of the professional and agricultural activities of this group, as the highest infection rate was recorded among males (23.29%), which reflects increased exposure in work and agricultural environments. As for females, the rate was higher in the age group (10-14) years compared to the rest of the age groups. The possible reasons for the high infection rate in young age groups and males may be due to increased physical activity and interaction with animals, lack of awareness about the danger of rabies in rural communities, weak vaccination campaigns for pets and stray animals, and failure to adhere to preventive measures after animal bites (Rotivel, 2012; Adamson, 1977; Reece and Chawla, 2006). When comparing our study with other studies, there was a study by the World Health Organization (WHO) that indicated that (70%) of rabies infections worldwide occur among males, especially in the young and youthful age groups (10-19) years due to increased interaction with animals. A study in India (2021) found that (65%) of infections occur among males, with the highest rate recorded in the age group (10-19) years, which is consistent with the results of Table (7) and other tables. A study in Nigeria (2022) indicated that the age group (15-44) years is the most exposed to rabies, due to increased contact with animals in rural environments (Smith et al., 2019; Kumar et al., 2020; WHO, 2014; WHO, 2023; NASPHV, 2007). The World Health Organization

(WHO) stated that (40%) of rabies victims are children under the age o f (15) years, which explains the high rate of infection in young age groups (NASPHV, 2007; Harris, 2012; WOAH, 2020). Thus, the results of our tables are consistent with global findings and trends in rabies infection rates.

Table (3): Total number and rates of rabies infections by age group for both sexes in the year 2020

Group Number	Age Group / Year	Number of Male	Percentage %	Number of Female	Percentage %	Total number	Percentage %
1	4 ≥ 1	9	2.34	4	1.04	13	3.38
2	(9 - 5)	44	11.43	21	5.45	65	16.88
3	(14 -10)	37	9.61	54	14.03	91	23.64
4	(19 -15)	32	8.31	65	16.88	97	25.19
5	(44 -20)	43	11.17	41	10.65	84	21.82
6	(64 -45)	13	3.37	18	4.68	31	8.05
7	65 ≥	3	0.78	1	0.26	4	1.04
Total		181	47.01	204	52.99	385	100

Table (4): Total number and rates of rabies infections by age group for both sexes in the year 2021

Group Number	Age Group / Year	Number of Male	Percentage %	Number of Female	Percentage %	Total number	Percentage %
1	4 ≥ 1	14	3.27	8	1.87	22	5.14
2	(9 - 5)	35	8.19	44	10.28	79	18.47
3	(14 -10)	74	17.28	34	7.95	108	25.23
4	(19 -15)	45	10.51	30	7.01	75	17.52
5	(44 -20)	63	14.72	42	9.81	105	24.53
6	(64 -45)	18	4.21	12	2.80	30	7.01
7	65 ≥	7	1.63	2	0.47	9	2.10
Total		256	59.81	172	40.19	428	100

Table (5): Total number and rates of rabies infections by age group for both sexes in the year 2022

Group Number	Age Group / Year	Number of Male	Percentage %	Number of Female	Percentage %	Total number	Percentage %
1	4 ≥ 1	0	0	1	0.18	1	0.18
2	(9 - 5)	13	2.39	21	3.85	34	6.24
3	(14 -10)	64	11.74	54	9.91	118	21.65
4	(19 -15)	102	18.72	70	12.85	172	31.57
5	(44 -20)	89	16.33	42	7.71	131	24.04
6	(64 -45)	57	10.46	21	3.85	78	14.31
7	65 ≥	10	1.83	1	0.18	11	2.01
Total		335	61.47	210	38.53	545	100%

Table (6): Total number and rates of rabies infections by age group for both sexes in the year 2023

Group Number	Age Group / Year	Number of Male	Percentage %	Number of Female	Percentage %	Total number	Percentage %
1	4 ≥ 1	19	3.54	21	3.91	40	7.45
2	(9 - 5)	43	8.01	49	9.12	92	17.13
3	(14 -10)	67	12.48	60	11.17	127	23.65
4	(19 -15)	48	8.94	57	10.61	105	19.55
5	(44 -20)	59	10.98	62	11.55	121	22.53
6	(64 -45)	16	2.98	20	3.73	36	6.71
7	65 ≥	7	1.30	9	1.68	16	2.98
Total		259	48.23	278	51.77	537	100%

Table (7): Total number and rates of rabies infections by age group for both sexes in the year 2024

Group Number	Age Group / Year	Number of Male	Percentage %	Number of Female	Percentage %	Total number	Percentage %
1	4 ≥ 1	3	0.93	1	0.31	4	1.24
2	(9 - 5)	8	2.49	11	3.42	19	5.91
3	(14 -10)	55	17.08	27	8.38	82	25.46
4	(19 -15)	57	17.70	29	9.01	86	26.71
5	(44 -20)	75	23.29	30	9.32	105	32.61
6	(64 -45)	16	4.97	7	2.17	23	7.14
7	65 ≥	2	0.62	1	0.31	3	0.93
Total		216	67.08	106	32.92	322	100%

Table (8) and Figure (2) represent the results of our study on the relationship between rabies infection and the months of the year. The table shows that the highest rates of rabies infection were recorded in September and October, with percentages of (12.54%) and (12.13%), respectively. These data show an increase in infection rates during the moderate months (September and October), which is consistent with a study conducted in Nigeria in 2022. The study found that rabies spread increases during moderate seasons due to increased movement of animals and the spread of stray dogs. This could be related to an increase in outdoor activities and exposure to stray animals during these months, when the temperature is moderate, and interaction with the outdoor environment is higher (WOAH, 2020). On the other hand, the lowest infection rates were observed in June (5.5%) and December (4.74%), possibly due to reduced human activity caused by cold or hot climatic factors, which is consistent with studies (Denduangboripant et al., 2025; WHO, 2023; Oluwaseun et al., 2022). Overall, the difference in infection rates between males and females showed that the infection rate in males was (56.25%) with (1247 cases), while the rate in females was (43.75%) with (970 cases), indicating that males are more susceptible to infection. These results align with a study published in the Journal of Infectious Diseases (Smith et al.,2019), which indicated that males in developing countries are more likely to be infected with rabies due to increased exposure to stray dogs and outdoor activities. We also observed variation in infections between males and females across different months of the year, but infection rates remained higher in males across all months. This difference is more pronounced in months with higher activity, such as September, where the number of cases was (128 cases in males versus 150 cases in females), while in January, the number of cases was (103 cases in males versus 157 cases in females).As for infection rates in moderate months by age group, we found that age groups between (15–19) years and moderate months like September and October were more susceptible to infection due to increased interaction with animals in this age group, which aligns with the current study data (Smith et al., 2019 ; WHO , 2023 ; Harris , 2012).

Table (8): Total number and rates of rabies infections for both sexes throughout the months of the year

The months of the year	Total Number of infected cases	Percentage %	Number of Male	Percentage %	Number of Female	Percentage %
January	260	11.73	103	4.65	157	7.08
February	199	8.97	93	4.19	106	4.78
March	230	10.38	119	5.37	111	5.01
April	134	6.05	103	4.65	31	1.40
May	163	7.35	116	5.23	47	2.12
June	122	5.5	98	4.42	24	1.08
July	126	5.68	96	4.33	30	1.35
August	219	9.88	123	5.55	96	4.33
September	278	12.54	128	5.77	150	6.77
October	269	12.13	102	4.60	167	7.53
November	112	5.05	88	3.97	24	1.08
December	105	4.74	78	3.52	27	1.22
	2217	100	1247	56.25	970	43.75

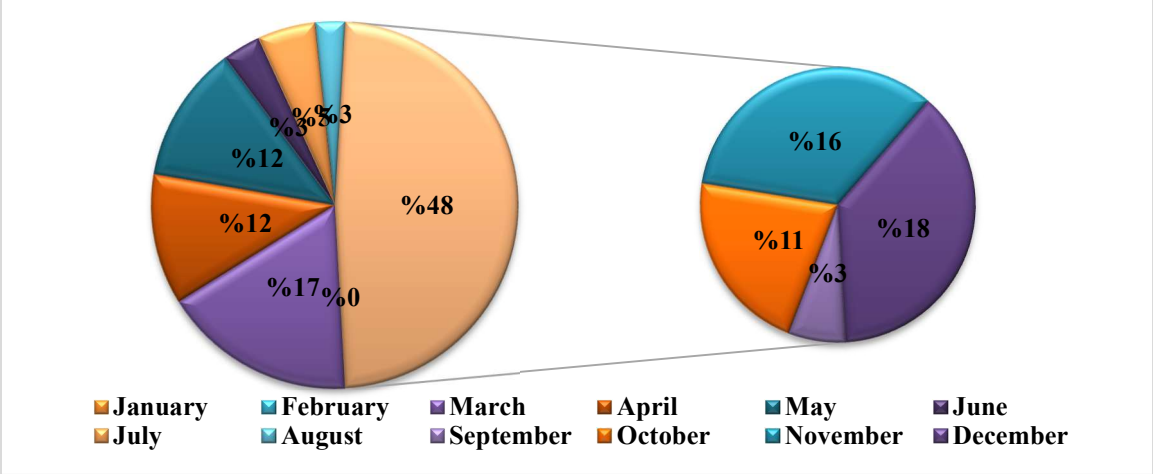

Figure (2): Total number and rates of rabies infections for both sexes throughout the months of the year

Table (9) and Figure (3) the relationship between infection and residential sectors, show the distribution of rabies cases in the different residential sectors. We find that the highest infection rate was in Al-Hussainiya sector, with (43.93%), with (974 cases), followed by Al- Hindia sector with (35.5%), with (787 cases), then Al-Hur sector with (290) cases, with (13.08%). The lowest number and infection rate, respectively, was in the central sector (166), with (7.49%), which is consistent with (WHO, 2023; Oluwaseun et al., 2022). These results may indicate that sectors with higher population density, such as Al-Hussainiya sector, are more susceptible to infection due to increased interaction between residents and stray animals. There are also some factors influencing the spread of the disease in Al-Hindia and Al-Hussainiya sectors. There may be an increase in the number of stray or infected dogs due to the lack of dog control, leading to greater exposure to these dogs, which explains the higher incidence in these areas; Environmental and service influences also play a significant role in the spread of rabies. For example, sectors with a lack of veterinary health services or vaccination campaigns may be more susceptible to disease outbreaks (Patel et al., 2021; Oluwaseun et al., 2022). Community awareness and

preventive programs may contribute to reducing the spread of the disease in residential areas. On the other hand, the low rate in the central sector can be attributed to the small number of stray or infected dogs; It may also be less densely populated or have better preventive measures such as the presence of health and animal care services, consistent with (Patel et al., 2021; Oluwaseun et al., 2022), where these studies indicate that rural and suburban areas that witness an increase in the number of stray dogs are more vulnerable to the spread of the disease due to the greater interaction of residents with animals, while in urban areas protection is better thanks to veterinary care services and control of numbers of dogs (Denduangboripant et al., 2025; Harris, 2012; Oluwaseun et al., 2022). This disparity underscores the importance of promoting awareness and preventive techniques in rural areas.

Table (9): The number and percentage of people infected with rabies by residential sector

Residential Areas / Sector	Number of infected cases	Percentage %
Center	166	7.49
Al- Hindia	787	35.5
Al-Hussainiya	974	43.93
Al-Hur	290	13.08
Total	2217	100

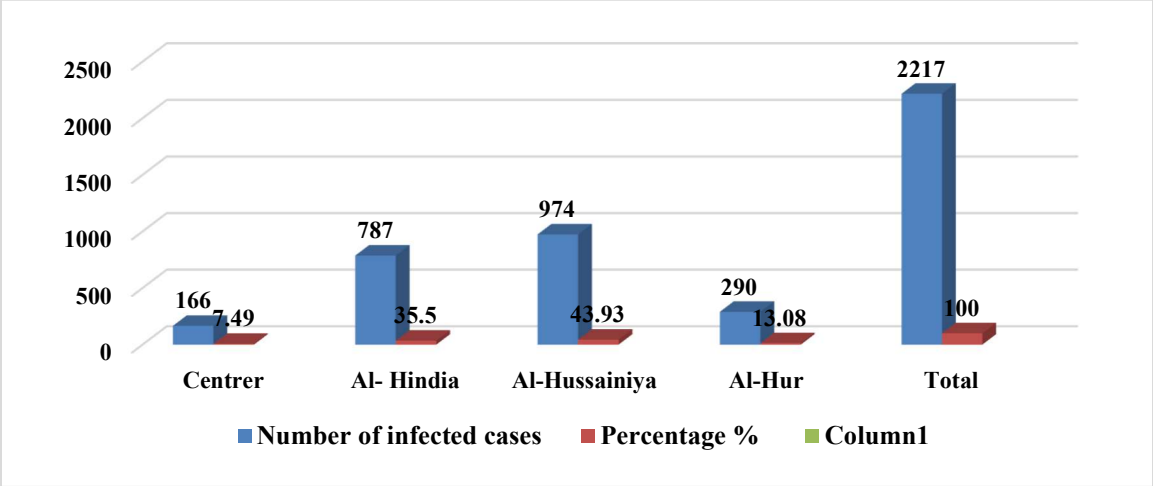

Figure (3): The number and percentage of people infected with rabies by residential sector

Conclusions

- The data indicates that the infection rate is higher among males than females.
- A clear variation is observed between urban and rural areas in terms of infection rates.
- The highest infection cases were in the age groups of adolescence and youth (10-14 years) and (15-19 years), while the lowest infection rates were observed in the very young (≤ 4 years) and the very old (≥ 65 years) age groups.

Recommendations

- Intensify awareness campaigns about the risks of rabies in the community in general, with a focus on rural areas and age groups most vulnerable to infection.
- Launch regular vaccination campaigns targeting stray dogs and pets to reduce the spread of the virus.
- Enhance the speed of medical response when bitten or suspected of rabies exposure by improving emergency services and providing preventive treatments.
- Provide vaccination and follow-up centers in rural areas and high-risk communities to ensure easy access to healthcare services.

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